The Dissertation Committee for Chao-hsiu Chen Certifies that this is the approved version of the following dissertation:

Investigating the Influences of Teacher Belief and Contextual Factors on the Technology Integration of Taiwanese High School Teachers

Committee:

Todd Reimer, Supervisor

Lisa Goldstein

Marilla D. Svinicki

Hsin-liang Chen

Mary Lee Webeck

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by

Chao-hsiu Chen, B. Ed.; M.A.

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Chao-hsiu Chen, Ph.D.

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Supervisor: Todd C Reimer

The purposes of this study were to illustrate the technology integration of Taiwanese high school teachers, to explore the influence of the teachers' pedagogical beliefs and beliefs about the potential of technology for their technology integration, and to investigate how contextual factors affect teacher belief and practice related to technology usage. Twelve Taiwanese high school teachers were recruited to participate in this project. With the interpretivist paradigm and qualitative case study methods, data were collected from classroom observation, interviews, and reviews of documents. The findings of this study can inform researchers and practitioners about how to improve the technology integration of Taiwanese high school teachers, and the findings can also provide different perspectives on the implementation of an educational innovation at different grade levels and at different educational systems.

The study found that teachers' pedagogical beliefs and beliefs about technology integration were not primary factors influencing technology integration. Instead, comparative analysis indicates primary mitigating factors were teachers' concerns regarding obstacles to technology usage in classroom. Nevertheless, teachers'

pedagogical beliefs and beliefs about how technology could help them achieve their instructional goals did affect their perception and practice of technology integration. Teachers with more constructivist beliefs made efforts to allocate time for students to engage in problem- or project-based learning occasionally. Some of them used online discussion or presentation software to anchor and encourage discussion and interaction among teachers and students. Teachers who prioritized examination preparation mostly used technology to cover content, sometimes discarding technology when they considered technology not cost-effective or a distraction for student learning.

The analysis of the influences of context factors on technology integration focused on the context of Taiwanese high schools. The College Joint Entrance Examination, the mandatory curriculum standards, adopted textbooks, and inflexible assessment methods allowed teachers limited time and freedom to integrate technology with creative instruction design. The available equipment and support from others could be another issue, and the attitudes of other stakeholders could give teachers either pressure or support. Finally, school culture as well as issues of racial, social, and culture difference should be considered while promoting technology integration.

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Chapter 1: Introduction

With the development of educational technology, schools have been making efforts to acquire equipment and to encourage teachers to integrate technology with their instruction. However, research findings indicate that there was limited technology usage in most classrooms, and the technology integration in Taiwan faced a similar problem. Research indicates that teacher belief could be a critical factor facilitating or hindering teachers' technology integration. Various contextual factors could also affect teacher belief and technology integration, and these contextual factors should be addressed simultaneously because their relationships with teacher belief and technology integration may not be linear and isolated.

Therefore, this study examined how Taiwanese high school teachers integrated technology in their instruction and how teacher belief and contextual factors influenced the teachers' technology integration. Twelve Taiwanese high school teachers participated in this project. With the interpretivist paradigm and qualitative case study methods, data were collected from classroom observation, interviews, and review of documents. The findings of this study can provide educational practitioners and researchers with suggestions about how teacher belief and contextual factors interplay to affect teachers' technology integration, and with alternative perspectives on how to implement technological innovations in educational systems.

STATEMENT OF THE PROBLEM

The development of educational technology has changed dramatically, and so has technology integration in education. Research findings show that teachers who have more computers or Internet connections in their classrooms tend to use educational technology more in their instruction, in lesson preparation, and in communicating with colleagues, parents and students (e.g. Smerdon et al., 2000). However, technology integration does not simply mean using word processing software to create documents, having students use drill-and-practice software to strengthen basic skills, or using slides and projectors to support lectures. In fact, technology can be incorporated with instruction in more meaningful and creative ways to help students learn subject matter and gain deeper understanding (Goldman et al., 2002; Schwartz et al., 1999; Williams et al., 1998).

However, several large-scale studies indicated that there was limited technology usage in classrooms (Becker, 2000a; Becker, Ravitz & Wong, 1999; Hart, Allensworth, Lauen, & Gladden, 2002; NetDay, 2001; Smerdon et al., 2000). Cuban (2001) stated that although some people believe that putting computers into classrooms, connecting classrooms to the Internet, and asking teachers to incorporate technology into classrooms will lead to more constructivist-type instruction, still others believe that whether new technology results in critical change in classrooms is highly dependent on teachers' acceptance of the technology. Transforming technology usage from transmitting knowledge to fostering students' understanding does not occur automatically, and teachers' beliefs usually play a critical role in this transformation process (e.g., Ertmer, 2005; Sandholtz, Ringstaff, & Dwyer, 1991, 1997; Windschitl & Sahl, 2002).

No matter how researchers or administrators promote technology integration, teachers are the people who decide how to implement technology integration in their classrooms. Even with the same equipment, teachers with different beliefs and attitudes about instruction usually have very different perspectives on technology integration, and therefore achieve different outcomes (Hodas, 1993; Windschitl & Sahl, 2002). Although research findings indicate the close relationship between teacher belief and technology usage and many studies address the influence of teacher belief on classroom instruction of mathematics, reading and science, little research focuses specifically on how teacher belief affects technology integration in classrooms (Ertmer, 2005).

Moreover, the expressed teacher belief may not be consistent with the implemented practice, and various contextual factors could cause this inconsistency (Ertmer, 2005). Teachers have to resolve conflicts between organizational support and constraints to achieve consistency between their beliefs and practices (Tabachnick & Zeichner, 2003). Numerous studies investigate what contextual factors may affect technology integration (e.g., Bitner & Bitner, 2002; Bullock, 2004; Cuban, 2001; Cuban et al., 2001; David, 1996; Dexter, Anderson & Becker, 1999; Doering, Hughes, & Huffman, 2003; Hart et al., 2002; King, 2002; Mouza, 2002-2003; OTA, 1995; Pfundstein, 2003; Strudler & Wetzel, 1999; Tyack & Cuban, 1995), and the list of the contextual factors seems to be endless. However, finding and categorizing all contextual factors may not be useful for understanding teachers' decision-making on technology integration because different contextual factors may interact dynamically (Woods, 1996). Furthermore, Zhao et al. (2002) argued that the values of such studies can be limited if they do not clarify the characteristics of each factor, the applied context of the factors, and the relationships among different factors. Similarly, Blumenfeld, Fishman, Krajcik, & Marx (2000) and Hung & Koh (2004) considered different factors surrounding teachers as interrelated, and they suggested that simply addressing isolated issues will not lead to successful technology integration and transformation of instruction.

Understanding that education quality may be improved through promoting technology integration, the Ministry of Education of Taiwan (i.e., the education department of Taiwan's central government) proposed a plan to create the Information Education Infrastructure as a component of its Educational Reform Action Program from 1999 (Ministry of Education, 2001a, 2002a). The government allocated about five billion dollars to conduct this five-year program, which included 12 main projects. Since 1999, the Ministry of Education has continually reviewed and revised educational policies to establish technology-rich environments in public elementary and secondary schools and to encourage teachers to incorporate technology into instruction (EduCities, 2001; Ministry of Education, 2001b, 2002b, 2002c, 2003, 2004, 2005). Researchers have been invited to evaluate the effectiveness of the technology plans (Ministry of Education, 2000, 2003, 2004, 2005).

Although Taiwan’s government is aware of the possible achievements in learning brought by technology usage, encouraging teachers to integrate technology in their classrooms remains a challenge. A nationwide survey conducted by *Common Wealth* magazine in 2000 identified the issue of limited technology integration in most teachers’ classrooms in Taiwan. The survey investigated elementary and junior high school teachers’ ability to apply information technology to their instruction. Data from 2,965 teachers were collected, and the findings claimed that only 19.9% of the teachers could competently integrate technology with teaching and learning activities. Moreover, 73% of the teachers used technology in their classes less than one hour per week (Lee, 2001).

Even though government reports indicated gradual improvement in equipment accessibility and more frequent technology usage in classrooms (Ministry of Education, 2004, 2005), recording the number of available computers and hours spent using computers and the Internet did not reflect how teachers incorporated technology into their instruction. Teachers may use technology to facilitate knowledge transmission rather than to foster student understanding. In addition, although some studies investigated factors or barriers affecting the technology integration of Taiwanese teachers (e.g., Chen, 2003; Chen, 2004; Hsu, 2003; Wang, 2004), none of the studies identified how teacher beliefs and contextual factors interplay to influence technology integration.

PURPOSE OF THE STUDY

This study explored the technology usage of Taiwanese high school teachers. The investigation focused on how teacher belief influenced the teachers' technology integration and on what and how contextual factors surrounding the teachers affected teacher belief and their decision and practice regarding technology usage.

In an article reviewing studies on teacher belief and its implications in technology integration, Ertmer (2005) suggested that more research should pay attention to the relationship between teacher belief and technology integration. Her discussion about teacher belief focused on pedagogical beliefs, which referred to their educational beliefs about teaching and learning and on beliefs about how technology can help teachers implement those pedagogical beliefs in classrooms. Following her recommendations, this study focuses on teachers' pedagogical beliefs and their beliefs about the potential of technology for facilitating the implementation of those pedagogical beliefs.

As previously mentioned, the inconsistency between teacher belief and practice may result from the influences of contextual factors which interact with one another to support or hinder teachers in putting their beliefs into practice. While investigating and analyzing contextual factors and their influences on teacher belief and technology integration, researchers should not consider each context factor separately. Fullan (2001) indicated that while undertaking an educational innovation, the analysis of that innovation is usually oversimplified and different factors may interactively affect the implementation of an innovation at different times and situations. To achieve successful implementation of an innovation, Fullan suggested, various contextual factors should be considered and tackled together.

Therefore, this study's purposes were to investigate how Taiwanese high school teachers' pedagogical beliefs and their beliefs about the potential of technology for achieving their pedagogical beliefs influence their technology integration, and to illustrate how contextual factors surrounding the teachers affect their beliefs and practices.

RESEARCH QUESTIONS

This study investigates the following three questions:

1. How do the teachers incorporate technology into their instruction?
2. How the teachers' pedagogical beliefs and beliefs about the potential of technology for achieving their instructional goals influence their practices?
3. What are the contextual factors surrounding the teachers and how do they affect their beliefs and technology integration?

THEORETICAL FRAMEWORK

Currently, proposed instructional theories, teaching strategies, and technology integration are mostly aligned with the concepts of constructivism (Jonassen, 2002; Jonassen & Land, 2000; Reigeluth, 1999). According to constructivism, learners actively construct their understanding based on their prior experiences and existing knowledge structures (Ginsburg & Opper, 1988, Greeno, Collins, & Resnick, 1996). Through interacting with environments, tools, and other people, learners gradually apprehend the shared knowledge, language, and culture (Greeno et al., 1996; Lave & Wenger, 1991; Wells, 2000). In constructivist education, the teacher designs learning activities to engage students in active problem solving and genuine inquiry. The learning tasks are designed to be authentic and challenging to motivate students. Multiple viewpoints are encouraged, and students can discuss and debate their opinions. Studies indicate that learning with technology can foster student understanding by engaging students in higher-order thinking, self-regulated learning, and collaborative/cooperative learning (Jonassen, 2003; Jonassen, Howland, Moore, & Marra, 2003; Lowyck & Elen, 2004).

Moreover, some research findings imply a connection between teachers' technology usage and their constructivist beliefs and instruction. For example, Ertmer, Gopalakrishnan, & Ross (2001) reported that on one hand technology may facilitate the process of implementing teachers' constructivist beliefs, and on the other hand technology usage may support teachers to transform their beliefs and practices into constructivist ones. Although constructivist instruction is not necessarily derived from technology usage, technology usage may facilitate and support teachers' constructivist practices. As a result, there have been increasing expenditures on equipment acquisition (Meyer, 2001; Parsad & Greene, 2005; Skinner, 2002). Moreover, commonly recognized educational technology standards for students, teachers, and administrators are being developed and adopted (ISTE, 1998, 2000, 2001, 2004). Therefore, the promoted technology integration including research literature, educational technology standards and policies suggest the advantages of combining technology with constructivist instruction.

Figure 1.1 illustrates a general theoretical framework guiding the data collection and data analysis. The proposed technology integration is to combine technology with constructivist instruction. Teachers' pedagogical beliefs influence their technology integration. In addition, contextual factors surrounding teachers affect teacher belief and practice. The arrows in this figure are all two-way to signal that the relationship between teacher belief and practice is interactive and reciprocal (Borko, Davinroy, Bliem, & Cumbo, 2000; Fullan, 2001; Richardson, 1994), as are the relationships among contextual factors, teacher belief, and teacher practice.

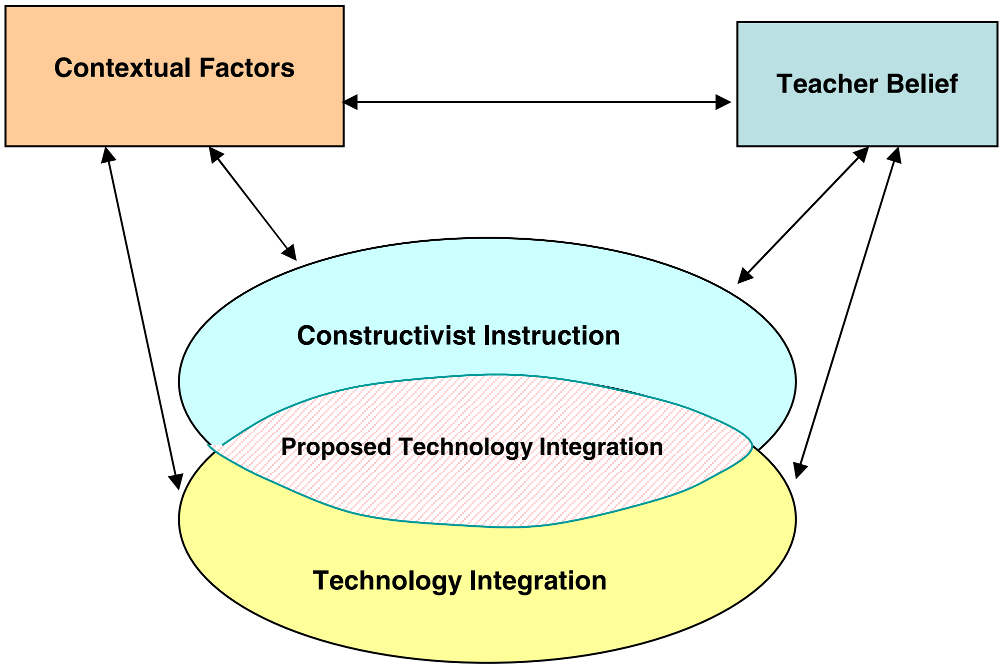


Figure 1.1 Theoretical Framework

ANALYTICAL FRAMEWORK

The interpretivist paradigm (Schwandt, 1998; Howe, 2001) and qualitative case study methods (Merriam, 2001) constituted the analytical framework of this study, because the study's purposes were to infer and interpret the beliefs of participants and to explore the influence of other contextual factors on teacher belief and practice. Purposive sampling can increase the range of data and maximize the possibilities of uncovering multiple realities (Lincoln & Guba, 1985). Therefore, to obtain abundant information related to the focus of the study, this study was conducted in a public high school located in Taipei, where I anticipated that the teachers probably undertook projects of technology integration more often. Twelve teachers participated in this study, and data were collected from class observations, interviews, and documents.

While continually making comparisons and generating concept-related questions (Glaser, & Strauss, 1967; Strauss& Corbin, 1998), all raw data were coded into categories, and the categories were modified throughout the study. Techniques such as prolonged engagement, persistent observation, triangulation, peer review and member checking were used to ensure research quality (Lincoln & Guba, 1985). Among the twelve participants, four cases were chosen to present the findings because the four teachers possessed critical characteristics shared by other participants.

SIGNIFICANCE OF THE STUDY

Instead of concentrating on instructional strategies and teacher behavior, more research is needed to understand the role of teacher belief in promoting the use of proposed instructional strategies (Albion, & Ertmer, 2002; Ertmer, 2005; Richardson, 1996). Although numerous studies recognize the importance of teacher belief in the implementation of a technological innovation (e.g., Bitner, & Bitner, 2002; Dexter et al., 1999; Ertmer, 1999, 2005; Fisher, Dwyer, & Yocam, 1996; Niederhauser & Stoddart, 2001; Ravitz, Becker, & Wong, 2000; Sandholtz, et al., 1991, 1997; Windschitl & Sahl, 2002), there is little research that specifically addresses the connections between teacher belief and teacher practice in technology integration (Ertmer, 2005). The purpose of this study was to help fill this gap by exploring the relationships between teachers' beliefs and technology integration.

While noting the numerous studies that have summarized various contextual factors and obstacles related to technology integration, Zhao & Frank (2003) argued that these factors surrounding teachers do not linearly affect their technology integration. Simply finding correlations between various factors and technology integration cannot address the complexity of the interrelationships among teachers' perceptions, various contextual factors, and teaching practices. To accurately present the complexity of teachers' decisions and practice of technology integration, this study specified, analyzed, and illustrated the characteristics of contextual factors, the research contexts, and interrelationships of these factors.

Furthermore, although conducting research about technology integration in a technology-rich environment can explore possible applications and improvement in instruction resulting from technology usage (e.g., Sandholtz et al., 1991; 1997), there are very few schools equipped with high-end educational technology. The findings of Ertmer et al. (2001) concluded that the perceived and practiced exemplary technology usage in K-12 classrooms is not necessarily aligned with the best practice suggested in the literature. Therefore, Ertmer et al. suggested that the literature should illustrate more examples of how teachers could modify their constructivist practices to handle the constraints and conflicts surrounding them and highlight the teachers' strategies of implementing technology integration in different phases. In the studied school, although the teachers accessed more resources and support compared with teachers in other schools, the resource and support differences between the schools were not very significant because of the centralized management of educational policies and practices in Taiwan. The description of how the participants interacted with contextual factors to incorporate technology into their day-to-day teaching should reflect the experience and understanding shared by most teachers.

Finally, while large-scale surveys can reveal the general situations of technology integration in most schools, the data may not uncover relevant issues in depth (Hadley & Sheingold, 1993). Also, data collected from surveys may not truly reflect teacher beliefs because teachers may not know how to examine and express their belief (Fullan, 2001; Kagan, 1990; Richardson, 1994). This study employed qualitative research methods to investigate and document the participants' beliefs, contextual factors surrounding them, and their technology integration in detail through prolong and persistent observation and interviews. The findings should be able to provide researchers and other practitioners with perspectives different from the results derived from large-scale surveys. Moreover, through reading the particularities and similarities presented in this study, researchers and practitioners of different educational systems may interpret the findings, draw their own conclusions, and apply the concepts and issues to their future work (Stake, 1978, 1995, 1998).

DEFINITIONS OF TERMS

(Educational) Technology: Educational technology includes the computer hardware and software used to support teaching and learning. It can be desktop, laptop, and handheld computers, a variety of software, computer networks, and peripherals such as digital cameras, printers, scanners, LCD projects, and digital storage equipment.

Technology Integration: Technology integration is the incorporation of educational technology into teachers' daily routines, instruction, management work, and so on. However, the technology integration referred to in this study focuses on the technology usage of teachers to support teaching and learning activities. This term is used interchangeably with technology usage.

Pedagogical Beliefs: Pedagogical beliefs are teachers' educational beliefs about learning and teaching. For example, teachers holding constructivist pedagogical beliefs may believe students need to construct their knowledge actively, and they allow students more flexibility to explore knowledge and solve problems on their own.

Professional development: Professional development is the formal or informal programs and training provided for teachers to help them acquire new skills or understanding about new educational theories, pedagogy, instructional strategies, and so on. The professional development mentioned in this study is the opportunity offered to the teachers to advance their technology usage.

Learner-Centered Instruction: In learner-centered instruction, teachers pay close attention to students' prior knowledge, misconceptions, and cultural issues, and teachers respect these differences and try to help students construct their knowledge based on prior knowledge, experiences and understandings (Brandsford, Brown, & Cocking, 2000).

Project-Based Learning: Project-based learning is the use of a complex, authentic and meaningful question to engage students in a process of creating a product with technology. Students collaboratively learn and apply knowledge during the process (Krajcik et al., 1998).

Problem-Based Learning: Problem-based learning is similar to project-based learning; however, it anchors student learning by asking students to collaboratively solve an open-ended, challenging and complex problem. Teachers play the role of a facilitator to provide necessary help during the problem-solving process (Cognition and Technology Group at Vanderbilt, CTGV, 1990, 1992).

Self-Regulated Learning: Self-regulated learning means that students metacognitively, motivationally, and behaviorally participate in their own learning. The students "plan, set goals, organize, self-monitor, and self-evaluate at various points" (Zimmerman, 1990, p.4) during the learning process.

Modeling: Modeling means that teachers demonstrate how to solve problems to make their cognitive and metacognitive strategies overt to students (Collins, Brown, & Newman, 1989).

Scaffolding: “A process that enables a child or novice to solve a problem, carry out a task, or achieve a goal which would be beyond his unassisted efforts" (Wood, Bruner, & Ross (1976, p.90).

Coaching: To play the role of a coach, teachers choose appropriate tasks for students to perform, divide students into groups to conduct collaborative/cooperative learning, provide useful feedback, use challenging questions to foster students' critical thinking, give encouragement to motivate students and engage them in learning activities, and help students correct their misconceptions (Torp & Sage, 1998).

The High School/College Joint Entrance Examination: In Taiwan, after finishing junior high school, students have to take a district joint entrance examination to qualify for entry into senior high schools. To go to college, a senior high school graduate has to take the College Joint Entrance Examination. Students' scores in the joint examinations determine whether they are admitted to their preferred high schools or colleges.

Curriculum Standards: The Ministry of Education in Taiwan establishes curriculum standards for all subjects and grade levels from elementary school to senior high school. Textbook publishers must follow the standards and obtain approval for their published textbooks. Teachers choose their textbooks from those that have been approved.

Chapter 2: Conceptual Framework

The purpose of this study is to explore the technology usage of Taiwanese high school teachers. How the teachers' beliefs and various contextual factors interplay to influence their technology integration is the focus. This chapter reviews relevant literature to establish a conceptual framework for this study. Nowadays, the proposed instructional theories, teaching strategies, and technology applications are mostly aligned with the concepts of constructivism. Therefore, this review starts with clarifying the concepts of cognitive constructivism and social constructivism. Then, the promoted technology applications for fostering student understandings are described. The following section illustrates the technology usage in the U.S. classrooms including availability of equipment, standards and national plans related to technology integration, and issues or challenges about technology usage. Because teacher beliefs are commonly recognized as a key factor resulting in successful technology integration, the conceptualization of teacher beliefs and their relation to teaching practices are discussed. Also, the possible influence of teacher beliefs and other contextual factors on technology integration suggests the importance of this study. The final section provides a general description of the research context regarding the educational situations in Taiwan.

INSTRUCTIONAL THEORIES

Different researchers characterize educational theories and practices in different terms with different organizing principles, and different terms could share similar characteristics (Greeno et al., 1996). According to Greeno et al. (1996), there are three main perspectives of instructional theories. The first perspective is behaviorism. Behaviorist theories focus on strengthening the stimulus-response association. Using positive or negative reinforcements, instructors can gradually shape learners' behavior.

Therefore, behaviorist theories emphasize the importance of practicing learning tasks repetitively. The second category, cognitive theories, holds the view that learners construct their knowledge structures. Learners use cognitive and metacognitive strategies to process information. Cognitive theories emphasize the importance of understanding learners' existing conceptions and misconceptions, and then teachers can help them process new information or correct their misconceptions. The third perspective mainly relates to situated theories, in which knowledge is regarded as distributed and contextualized. Through interacting with tools used by learners, artifacts created in social activities, and environment including members of the learning community, learners construct their knowledge.

Theorists use different terms to explain how people learn, and syntheses of different perspectives are generated to provide a more holistic view of learning (e.g. Fosnot, 1996; Greeno & Moore, 1993; Wilson & Myer, 2000). According to the categorization of Greeno et al. (1996), so-called cognitive constructivism mainly derived from theories of Piaget belongs to the cognitive/rationalist view, while the theories of Vygotsky, which are usually the focus of social constructivism, belong to the pragmatist-sociohistoric view. Jonassen (2002) identifies three changes in the understanding of learning in contemporary theories. First, learners do not receive knowledge passively but create meanings actively. Second, learners not only make their meanings internally but also generate meanings through interacting with other participants. The third change involves the locus of meaning making. He argues, "[N]ot only does knowledge exist in individual and socially negotiating minds, but it also exists in the discourse among individuals, the social relationships that bind them, the artifacts that they use and produce" (p.46). These three changes conform to the points of cognitive constructivism and social constructivism.

Cognitive constructivism

According to cognitive constructivism, learning is a process of knowledge construction occurring within learners. Knowledge is the personal interpretation of experiences that learners encounter. Learners build or change their internal knowledge structures based on prior experiences, and the knowledge structures serve as the foundation for acquiring new knowledge. Learning is an active meaning-making process (Bendar, Cunningham, Duffy, & Perry, 1992). Therefore, knowledge should not be viewed as truth or facts that can be directly transmitted to learners' minds through instruction, because each person has a distinct interpretation of learning experiences. The learned experiences are represented with interrelated conceptual structures (Ginsburg & Opper, 1988). With the cognitive structures, learners perform general abilities such as such as reasoning, solving problems, and using and understanding language while facing new situations (Greeno et al., 1996).

If the results of a new situation fit the expectations, the learners do not have to modify their existing knowledge structures. People will not modify their cognitive structures if new contexts do not require them to do so, and their cognitive structures will remain stable and powerful (von Glaserfeld, 1987). Hence, learners tend not to learn in a situation which is compatible with their expectations. When learners cannot understand a new situation and cannot react to it appropriately, they will feel the tension of experiencing something novel or contradictory (Fosnot, 1996; von Glaserfeld, 1987). When people experience the tension, they need to extend or modify their cognitive structures so they can relieve the tension and retain a balanced condition (Fosnot, 1996; Ginsburg & Opper, 1988). This process of equilibration is critical for learning. Therefore, the ability to create new situations for learners to experience novelty and to encourage them to explore new knowledge is an important condition for learning (Wells, 2000).

However, when a new situation is far beyond the interpretation of an individual because the cognitive structures are not at an appropriate level, the individual may either ignore or distort the new information (Fosnot, 1996; Ginsburg & Opper, 1988; Roth, 1990). Hence, it is important to arrange a learning situation which is somehow compatible with students' cognitive structures while promoting a tension level which students can handle. If an individual has some misunderstanding and never experiences any contradiction or expectation failure, the knowledge structures are strengthened. Therefore, it is very important to find out learners' misconceptions, highlight the contradictions, and confront learners with their misunderstanding (Ginsburg & Opper, 1988; Kanuka & Anderson, 1999).

Social constructivism

The work of Vygotsky and his students is usually identified as "sociocultural" or "sociohistorical" theory that established the framework of social constructivism (Cole, 1985; Mayer, 2000; Palincsar, 1998). During the learning process, learners always interact with environments. Because environments are constantly changing, social constructivists proposed that the development of an individual can not be fully understood without paying attention to the history of the community which the individual participates in. Individual development is not only biological maturation but also an extended process of appropriating cultural inheritance while the individual is interacting with others in an activity (Wells, 2000). Vygotsky (1978) argued that any higher psychological function first appears on the "social plane" and then on the "psychological plane." When interacting with others, the relations between the learner and others are first "interpsychological" and, afterward, the psychological function within the learner is "intrapsychological" (Vygotsky, 1978, p.57, cited in Cole, 1985; Fosnot, 1996; Palincsar, 1998; Wells, 2000).

In general, theorists of social constructivism contend that people can learn from others through face-to-face interaction as well as through artifacts (e.g. material tools, language, knowledge, practices, etc.) created by other people (Wells, 2000). Knowledge is viewed as distributed among people of the same community and the social and material environment (Greeno et al., 1996). Activities in which knowledge is developed and applied can not be separate from learning. Learning situations are a part of learning, and the meaning of a concept is always under construction. Knowledge, just like tools, can only be fully understood in the context of use (Bendar et al., 1992; Brown, Collins, & Duguid, 1989). When people participate in the activities of a community, they depend on the resources, tools, and practices which the activity system affords to solve new problems. Through using these resources, tools, and practices which carry the experiences of the past, people appropriate the beliefs, values, knowledge and skills of the culture. People also rely on other members of the community in the appropriating processes (Lave & Wenger, 1991; Wells, 2000). Knowledge, activities, and culture are interdependent (Brown et al., 1989). Learning is not a separate and independent activity, but an integral aspect of participation in a community of practice (Cobb, 1996; Lave & Wenger, 1991).

A well-known term, Zone of Proximal Development (ZPD), was defined by Vygotsky (1978) as the difference between a child's "actual development as determined by independent problem solving" and the child's "potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p.86). This definition can be viewed as learners of different abilities and expertise taking different responsibilities and helping each other in a specific context. In a specific context, people have different knowledge and expertise (i.e. different ZPD), and they help each other to improve their development (Cole, 1985). By working with other members, the group members can go beyond their abilities to conduct a learning task which none could accomplish alone (Wells, 1999).

While learners change their understanding and identities by participating in an activity, the situated context or the practice can also be changed and renewed by the participants (Lave & Wenger, 1991; Rogoff, 1994; Wells, 1999; Wells, 2000). During their participation, all participants support and learn from each other to achieve their individual goals and, at the same time, change the collective knowledge and practices of the community (Lave & Wenger, 1991).

Synthesis of constructivist theories

In general, cognitive theorists focus on how individuals interpret a situation and organize the internal cognitive structures, whereas sociocultural theorists believe the psychological development of individuals results from the participation in activities and from social interaction. From the sociocultural perspective, learning is the appropriation of knowledge constructed socially and culturally through processes of interaction, negotiation, and collaboration (Cobb, 1996; Fosnot, 1996; Greeno et al., 1996; Palincsar, 1998).

In terms of school activities, cognitive theorists analyze the processes by which students actively interpret the interaction and organize internal structures while participating in the activities. Learning occurs personally and internally, but the teacher and the students have to coordinate their individual activities with each other. Meanwhile, sociocultural theorists view the activities as culturally organized practices, and students appropriate the understanding of the teacher and their peers by getting involving in the practices and interacting with others (Cobb, 1996). Consequently, sociocultural theorists tend not to analyze the individual differences in student thinking, and cognitive theorists eschew the analysis of the social and culture practices in the learning community.

Cobb (1996) suggested that learning is a process of self-organization as well as a process of enculturation and learning occurs while participating in cultural practices or interacting with others. Fosnot (1996) also recognized that the important point is not whether the individual or the culture should be prioritized in analyzing learning, but the interplay between the two. How individuals organize the cognitive structures cannot be fully understood without observing the processes in a context or in a culture. Moreover, individuals modify the internal cognitive structures to adapt to the external environments, so the cultural knowledge held by members of a community is actually "a dynamically evolving negotiated interaction of individual interpretations, transformations, and constructions" (Fosnot, 1996, p.24). Therefore, a thorough discussion of how people learn should focus on both culture and cognition and the interplay between the two.

Moving toward constructivist perspectives

Freire (1968) used a banking metaphor to criticize the traditional instruction model in which teachers simply considered how to deposit facts or concepts into students' heads efficiently. A similar metaphor regards schooling as the process of transforming raw materials (i.e. students) into the end product by technical works (i.e. the teachers) (Bennett & LeCompte, 1990; Callahan, 1962). These metaphors highlight the goal of efficiency, which has shaped the design of curriculum, instruction and assessment. However, researchers nowadays stress that teachers should foster student understanding rather than simply impart knowledge (e.g., Bransford, Brown, Cocking, 2000; Goldman et al., 2002; Jonassen et al., 2003; Jonassen, Peck, & Wilson, 1999; Wiggins & McTighe, 1998). The banking and factory concepts, they argue, cannot fulfill the goals of education.

Reigeluth (1999) advocated the importance of changing the paradigm of education from focusing on sorting to focusing on learning. The traditional paradigm based on standardization is much like mass production of industrial manufacturing, and teachers use norm-referenced assessments to rank students. Standardized instruction encourages comparisons and competition among students. The emphasis on conformity and compliance forms a school culture in which students are expected to sit quietly and follow the instructions given by the teachers. Reigeluth (1999) argued the paradigm of instruction needs to change from standardization to customization, from focusing on presenting materials to focusing on meeting learners' needs, and from putting things into learners' heads to helping students understand the learning process. The following necessary changes were identified to focus on learning: a shift from passive to active learning and from teacher-directed to student-directed or jointly directed learning; a shift from teacher initiative, control and responsibility to shared initiative, control and responsibility; a shift from decontextualized learning to authentic, meaningful tasks; and a shift from holding time constant and allowing achievements to vary to allowing each learner the time needed to reach the desired goal (p.19).

Similarly, Jonassen & Land (2000) proposed three shifts in thinking about learning. First, instead of knowledge transmission, learning should be understood as a process of meaning-making which can be either personally constructed, socially constructed, or both. Second, contemporary theorists must pay close attention to the social aspect of the meaning-making process. Learners construct knowledge through social negotiation and dialogue. Third, the process of meaning-making does not only occur in the learners' memory. As learners participate in an activity, their knowledge and beliefs are influenced by the practice and discourse of the community. Knowledge does not only reside in the head but also in the practice, the discourse, the social relationships, and the artifacts of the community.

Instructional design principles

Constructivism is not an instructional approach; rather, it is a theory about how people learn (Airasian & Walsh, 1997; Fosnot, 1996). There are not readily applicable instructional approaches of constructivism that teachers can implement in classrooms, nor are there explicit guidelines for teachers or instructional designers to create step-by-step instructional plans. However, the following general principles derived from constructivist theorists (Jonassen, 2003; Jonassen et al., 2003; Jonassen et al., 1999; Kanuka & Anderson, 1999; Koschmann, Kelson, Feltovich, & Barrow, 1996; Lowyck & Elen, 2004) may provide teachers with insights for designing and implementing their instruction.

First, learning is active and constructive. Instead of a process of adding knowledge to learners' heads, learning is a process of information interpretation and meaning construction actively conducted by learners. The learning environment should be learner-centered rather than teacher-centered. The instructional focus should not be simply on how to transmit knowledge to students by teachers or how to receive knowledge by students (Kanuka & Anderson, 1999). The invention and self-organization of learners constitute the development of learners. It is insufficient for learners to construct their understanding by listening to the experiences or findings of others (Barab& Duffy, 2000). Learners need to conduct learning tasks which require them to raise their own questions, generate their own hypotheses, solve their own problems, or test their own theories (Barab& Duffy, 2000; Darling-Hammond, Ancess, & Falk, 1995; Fosnot, 1996).

Second, learning is cumulative. Learners construct new knowledge by attributing meaning to the incoming information and integrating the meaning with their prior knowledge. Since learning is based on prior knowledge, teachers should not assume that all students can understand new information in the same way. Teachers should acknowledge that different students need different experiences to achieve different levels of understanding. In a learner-centered learning environment, teachers pay close attention to students' prior knowledge, misconceptions, and cultural issues. Teachers respect these differences and try to help students construct their knowledge based on prior knowledge, experiences and understandings (Brandsford et al, 2000; Kanuka & Anderson, 1999). Moreover, teachers should confront the misconceptions held by students so the students can be aware of the conflict between the new situations and their naive models (Fosnot, 1996; Kanuka & Anderson, 1999; Palincsar, 1998; Roth, 1990).

Third, learning is intentional and self-regulated. To achieve meaningful learning, learners need to have the intention to do so. Learners have to reflect on their own learning, and they manage and control the learning process. According to constructivism, learners construct their own understanding based on their existing cognitive structures (or mental models). The attained conceptions allow learners to advance their understanding because learners can generalize the conceptions in future learning (Perkins & Unger, 1999). Therefore, to facilitate knowledge construction by learners, much attention should be paid to general problem solving skills and metacognitive strategies (e.g., self-monitoring and self-evaluating) which learners can apply to new situations (Greeno et al., 1996). Metacognition enables learners to manage their own learning and encourages them to pursue their own interests. When learners encounter problems, they may resort to strategies such as monitoring their performance or revising their plans. Metacognition influences personal beliefs about learning, persistence with tasks, and self-efficacy of learners. By monitoring and evaluating their own learning, learners anticipate the possibility of success and determine the efforts they will invest in the learning tasks (Paris & Winograd, 1990). Also, asking students to reflect on what they have experienced helps them abstract knowledge into higher levels and construct stronger conceptual structures. Reflection provides students with the opportunity to detect where their understanding was inadequate and to correct their misconceptions (Barab & Duffy, 2000).

Fourth, learning is contextualized. Contexts affect the process of knowledge construction, and meaning making cannot be separated from the context, which refers to both physical as well as sociocultural environments. From a constructivist viewpoint, the content and context of learning are inseparable (Bendar et al., 2000; Brown et al., 1989; Spector, 2004). Therefore, learning environments should be authentic and complex to reflect the multiplicity feature of learning. Instruction should promote multiple viewpoints, representations, and strategies (Bendar et al., 2000; Shaffe & Resnick, 1999). Furthermore, students should be encouraged to participate in disciplinary practices using authentic tools, and to solve realistic problems in ways experts in the practices do (Bendar et al., 2000; Greeno et al., 1996; Shaffe & Resnick, 1999; Spector, 2004). Teachers should consider the current understanding of students and choose learning tasks which are valued and relevant to their real world experiences (Kanuka & Anderson, 1999; Koschmann et al., 1996; Spector, 2004). Also, to reflect the complexity of changing situations in the real word, Kanuka & Anderson (1999) argued that learning activities should be presented in an ill-structured way. Learning outcomes are both directed and emergent, and they cannot be completely prescribed in advance (Wells, 2000).

Finally, learning is socially negotiated. Learners co-construct meaning through participating in the learning activity. The classroom is regarded as a collaborative learning community. The social interaction can be face-to-face or mediated by artifacts created and utilized by other people (Wells, 2000). Therefore, teachers should provide an environment in which students can interact with materials, systems, concepts of the domain, and other learners (Greeno et al., 1996). Through negotiation, discussion, and argumentation in a social environment, learners can advance their intellectual development (Barab & Duffy, 2000; Palincsar, 1998). Therefore, to promote knowledge co-construction, teachers should provide opportunities for students to share their understanding. Multiple viewpoints should be encouraged and explored, and then students can reach a shared understanding through dialogue. Negotiating meanings and using conversational language facilitates the process of knowledge construction, so students need opportunities to defend, justify and communicate their ideas to the classroom community. How to create a risk-free environment in which students feel comfortable sharing different perspectives and engaging in argumentation and discussion is crucial for effective learning (Fosnot, 1996; Kanuka & Anderson, 1999).

TECHNOLOGY INTEGRATION

Goldman et al. (2002) argued that to foster student understanding, instruction should: (1) be organized around solving meaningful problems, (2) provide scaffolds for achieving meaningful learning, (3) provide opportunities for practice with feedback, revision, and reflection, and (4) promote collaboration and distributed expertise as well as independent learning. With educational technology, teachers can implement their instructional design to foster understanding more easily. Furthermore, technology can be a powerful tool for teachers to simplify their administrative tasks and improve professional development (Office of Technology Assessment, 1995). The following sections present various perspectives about technology integration, concrete examples of technology applications in education, research findings regarding technology usage in classrooms, and factors affecting technology integration.

Perspectives about technology integration

Most researchers would agree with Cuban's argument that we cannot expect to solve educational problems by putting technology into classrooms (Cuban, 2001). However, some researchers are still optimistic about the changes in curriculum and instruction that technology could bring to classrooms. Technology is regarded as an important element of constructivist approaches for fostering students' active knowledge construction rather than a tool simply transmitting facts and skills (President's Committee of Advisors on Science and Technology, 1997). For instance, the research of Rakes, Flowers, Casey, & Santana (1999) demonstrated a significant relationship between increased technology integration and constructivist instruction. The results indicated that teachers who increased the use of technology in their classrooms tended to adopt more constructivist instruction as well.

Similarly, Collins (1991) claimed that technology would transform instruction into a more constructivist style, and that students would construct their own understanding by carrying out challenging tasks with technology. He anticipated eight trends: (1) a shift from whole-class to small-group instruction, (2) a shift from lecture and recitation to coaching, (3) a shift from working with better students to working with weaker students, (4) a shift toward more engaged students, (5) a shift from assessment based on test performance to assessment based on projects, progress and effort, (6) a shift from competitive to a cooperative social structure, (7) a shift from all students learning the same thing to different students learning different things, and (8) a shift from the primacy of verbal thinking to the integration of visual and verbal thinking.

In addition, Nickerson (1995) stated that technology can help teachers deal with students' misconceptions, provide students with opportunities for processing and discovering knowledge actively, use dynamic and interactive representations to foster understanding, and create simulations and supportive learning environments. Another example of technology integration in education is the NET (Network for Education Testbed) project (Schofield & Davidson, 2002). This project demonstrated the possibilities of using the Internet to promote changes in teaching and learning. The researchers reported that the students became more autonomous learners, assumed different roles, such as tutors of the teachers who were learning educational technology, and had better relationships with the teachers. Furthermore, more people outside school were involved in curricular development activities, and the learning tasks became more authentic and contextualized because the students could connect to other academic communities or experts and obtain a variety of up-to-date information through the Internet.

Papert (1993) believed technology offers the best possible means to foster children's reflective thinking but he considered most practices in the area of "educational technology" or "computers in education" was simply mixing old instructional methods with new technologies. Likewise, Tunison (2002) advocated that educators should substantially change how they use technology rather than simply use it to replace old tools. Certainly, technology usage in teaching and learning can be adapted to direct instruction (e.g., drill and practice, tutorials). Moreover, applications such as problem-solving, multimedia applications and telecommunications can be used to enhance both direct and constructivist approaches. It depends on how teachers decide to integrate technology with the teaching and learning activities (e.g., Bitner & Bitner, 2002; Roblyer, Edwards, & Havriluk, 1997; Pierson, 2001; Zhao & Cziko, 2001). Jonassen (2000) explained traditional applications of computers in education are mainly learning "from" computers (i.e. computer assisted instruction, CAI) and learning "about" computers (i.e. computer literacy). Neither receiving knowledge delivered by CAI systems passively nor memorizing discrete knowledge about computers can promote critical thinking. Rather, learning "with" computers allows students to construct their understanding. Selected applications serve as various tools to create learning environments which can engage and enhance critical thinking and higher-order learning of students.

Using technology does not necessarily lead to higher-order thinking. Inappropriate technology usage may simply create trendy activities or even hinder learning (e.g., Bransford et al., 2000; Land & Hannifin, 2000; Lowyck & Elen, 2004). Lim & Tay (2003) emphasized that rather than technology, the lesson objectives and the aligned learning activities decide whether students will engage in higher-order thinking. Various types of technology could be combined to achieve lesson objectives. Goddard (2002) also suggested instead of simply delivering curriculum with technology, technology integration should focus on using technology as tools to support real-world applications, inquiry, composition, and communication. Such integration can foster creativity and engagement, and enhance learning. Moreover, Jonassen et al. (2003) said that technology usage should engage students in: (1) knowledge construction, not reproduction, (2) conversation, not reception, (3) articulation, not repetition, (4) collaboration, not competition, and (5) reflection, not prescription.

The following section provides more concrete examples of technology applications consistent with constructivist perspectives to promote knowledge construction, conversation, articulation, collaboration, and reflection.

Teaching for understanding with technology

Jonassen et al. (2003) listed five categories of technology applications for fostering student understanding. First, technology can provide a tool for representing learners' ideas, understandings, and beliefs. Technology such as multimedia can be used to produce organized presentations. Second, learners can use technology as information vehicles for exploring knowledge. With technology, learners can access needed information and compare it to various perspectives and beliefs. Third, technology can represent meaningful real-world problems or create seemingly authentic situations and contexts. It can also provide learners with a safe and controllable learning space. Fourth, with technology, learners can collaborate with others who are not physically present. Learners can discuss, argue and build consensus among members of a learning community. Finally, technology can support learners in reflecting upon what they have learned and how they came to know it. Technology can provide tools for learners to articulate and represent their internal negotiation and meaning-making, and therefore it can be used to encourage mindful thinking (Jonassen et al., 2003, p12).

Similarly, Brandsford et al. (2000) categorized five ways of technology usage for supporting learning: (1) bringing exciting curricula based on real-world problems into the classrooms; (2) providing scaffolds and tools to enhance learning; (3) giving students and teachers more opportunities for feedback, reflection, and revision; (4) building local and global communities that include teachers, administrators, students, parents, practicing scientists, and other interested people, and (5) expanding opportunities for teacher learning (p.207). Hung & Koh (2004) provided a similar categorization for technology integration in education. Further descriptions and examples of technology applications follow below.

Presenting learning tasks

In his model for designing constructivist learning environments, Jonassen (1999) emphasized using a driving question, case, problem, or project to engage students in solving problems and conducting active investigations. A major challenge for such inquiry-based learning environments is how to design interesting, complex, and authentic problems to engage students and, at the same time, to allow them to grasp the important concepts. Therefore, bringing learning tasks to students effectively is an important function of technology in inquiry-based learning activities (Cognition and Technology Group at Vanderbilt, 1990; Goldman et al., 2002; Pellegrino, 2004; Williams et al., 1998). For example, the Cognition and Technology Group at Vanderbilt University (CTGV) developed a series of instructional systems (e.g., Jasper Series, Scientists in Action Series, and Young Children Literacy Series) to engage students in solving complex, interesting and authentic problems (Barron et al., 1998). Each of these series contains video-based or animated stories. Following the narrative stories, students are presented a challenge which requires them to solve a complex problem based on the information provided in the system. The narrative video format motivates students and allows students of different mental development (e.g., poor readers) to handle the complexity and make connections between embedded information (e.g., mathematics concepts) and everyday situations. Also, students can revisit important segments to clarify their thoughts and improve their problem-solving strategies because of the video-disc formant (Barron et al., 1998; Brandsford et al., 2000; CTGV, 1990; CTGV, 1992; Williams et al., 1998).

Furthermore, numerous network-based learning environments provide various opportunities for students to undertake problem-solving and inquiry-based learning (Goldman et al., 2000; Jonassen et al., 1999; Jonassen et al., 2003). For instance, the Web-based Inquiry Science Environment (WISE) provides a learning environment in which students can examine real-world evidence and current scientific controversies (http://www.wise.berkeley.edu). Teachers can bring their students online and register as a class to conduct scientific projects. The WISE website includes various lesson plans, learning goals, and connections to national standards. Teachers can create original projects or use existing projects for engaging students in issues such as global ecology (Goldman et al., 2000; Jonassen et al., 2003; Linn & Hsi, 2000).

Scaffolding student learning

With educational technology, learners can conduct more advanced activities and perform more complex thinking and problem-solving tasks. Technology allows students to access a vast amount of information and supports data analysis, decision making, and artifact design (Blumenfeld et al., 1991; Brandsford et al, 2000; Jonassen, 1999; Pellegrino, 2004; Sheingold & Frederiksen, 1994). For example, the Jasper Adventure contains embedded teaching and information in video clips to scaffold the problem-solving process. These video scenes present important mathematic concepts, solution strategies, and focal points for classroom discussion (Barron et al., 1998; CTGV, 1990; CTGV, 1992; Williams et al., 1998). CTGV also developed different series of Jasper Adventures to facilitate knowledge transfer because learners can practice important concepts and problem-solving strategies in different Jasper discs (CTGV, 1990; CTGV, 1992).

In addition, learners can use technology as knowledge-modeling tools to create models and to make their knowledge explicit (Jonassen, 1999; Pellegrino, 2004; Shaffer & Resnick, 1999). Technology can simulate and model real situations or experiences to provide learners with authentic learning experiences (Jonassen et al., 1999; Jonassen et al., 2003; Seel & Dijkstra, 2004). For example, Model-It software contains scientific contexts such as ecosystems for students to test their hypotheses. Students can select certain variables from a list, define the relationships among the variables, and execute the models to observe the results. Also, they can input their collected data to test the result and report their findings. Therefore, students can make their understanding or misconception overt, and they can learn how to conduct scientific research as scientists (Jackerson, Stratford, Krajcik, & Soloway, 1996).

The WISE system also provides various resources and tools to support scientific investigation. Students can access a variety of Web resources, and pop-up windows allow students to take notes or to search for help. The WISE system divides each project into several sub-steps so students can navigate through different parts of content. Some hints are presented in the form of questions to engage students in deeper thinking. Tools such as data visualization, drawing flowcharts, evidence sorting, and online discussion are also provided (Goldman et al., 2000).

Feedback, reflection, and revision

Technology can provide tools that assist learners to articulate their understanding and provide feedback that enables learners to realize the effectiveness and accuracy of their performance and to analyze their actions and thinking (Jonassen, 1999). The interactivity of technology allows learners to revisit certain parts of learning activities to explore important concepts more thoroughly, to test their ideas, and to receive feedback. Therefore, learners have more opportunities to reflect on what they have learned as well as their own thinking process (Brandsford et al., 2000; Pellegrino, 2004). The aforementioned examples of technology applications all encourage students to revisit important concepts and to revise their actions or thinking. Simulation functions provided by the WISE system and Model-IT help students test their hypotheses, receive instant results, reflect on their thinking, and revise their ideas.

Furthermore, telecommunication promotes idea-sharing and exposes learners to various perspectives and explanations. They can compare their solutions or explanations with the ones generated by others. Learners can also make their work portable and accessible and then receive feedback from others (Brandsford et al., 2000; Jonassen et al., 2003; Sheingold & Frederiksen, 1994). A representative example is Knowledge Forum (http:// www.knowledgeforum.com), formerly called Computer Support Intentional Learning Environment (CSILE). Knowledge Forum is a collaborative database that supports asynchronous communication. The system allows learners from the same classroom, school or worldwide community to get involved in knowledge building activities (Goldman et al., 2000; Jonassen et al., 2003). Teachers can assign students thought-provoking and challenging questions or topics to investigate, discuss, and report on. Students post their notes into the database and comment on the notes of others. This environment provides more opportunities for students to receive feedback from peers, teachers, experts outside classrooms, and other interested people (Goldman et al., 2000; Scardamalia & Bereiter, 1996; Scardamalia, Bereiter, & Lamon, 1994). All learners in this environment can easily monitor the progress and transformation of the knowledge building because the database keeps all records. Moreover, teachers can conduct dynamic and ongoing formative assessment (Sheingold & Frederiksen, 1994; Williams et al., 1998).

Building learning communities

Educational technology provides learners with conversation and collaboration tools to facilitate discussion, collaborative inquiry, and artifact creation (e.g., Brandsford et al., 2000; Cohen, 1996; CTGV, 1998; Goldman et al., 2000; Jonassen, 1999; Jonassen et al, 2003; Shaffer& Resnick, 1999; Web-Based Education Commission, 2000; Williams et al., 1998). Collins & Bielaczyc (1997) proposed four dreams of learning communities which can be achieved with the networking technologies: the knowledge-society dream, telementoring dream, connected-classroom dream, teacher-community dream, and shared-passions dream. The first dream is inspired by the CSILE environment mentioned above, which highlights the knowledge building in the society formed by learners located in different places. With communication technology, students can contact adults who have relevant expertise and receive guidance from them. The Internet can also connect classrooms to discuss controversial issues or to conduct cross-classroom projects. Moreover, teachers can share their knowledge and experiences with other educational practitioners electronically. Finally, the network can bring learners of similar interests together and allow them to share their passions.

In Knowledge Forum, knowledge construction is a social activity. Learners from different places can contribute to the knowledge-building whenever they want. The communication among learners is not necessarily mediated by the teacher. People of different backgrounds and expertise can connect to the system to share and advance their knowledge (Scardamalia & Bereiter, 1996; Scardamalia et al., 1994). Besides connecting to adults of different expertise, conducting cross-school research projects engages students in working with a wider community (Scardamalia & Bereiter, 1996). Another example of working cross-classroom projects is the Global Lab project (http://globallab.terc.edu). This project brings students from different countries together to conduct scientific inquiry. Students gather data from their local environments for a global database. Students upload their data and download data collected by other schools. Then, they analyze the data and share findings with other participants of the Global Lab project (Berenfeld, 1994; Goldman et al., 2000; Jonassen et al., 2003; Web-Based Education Commission, 2000).

In terms of teacher learning, an online learning environment called TAPPED IN (http://www.tappedin.org) provides teachers with ongoing and flexible development programs and focuses on building an online community among educational practitioners (Goldman et al., 2000; Schlager & Schank, 1997; Web-Based Education Commission, 2000). The system is a multi-user virtual environment. Teachers can access the schedule for recent activities and attend various online development programs. They can bring their students to this virtual learning environment and communicate with other teachers and students (Schlager & Schank, 1997).

Technology integration in Classrooms

Although researchers depict promising ways of combining technology with prevalent instructional theories; whether various conditions in schools encourage the teachers to use technology in creative and meaningful ways decides how students can benefit from technology integration. It is necessary to examine the current situation of technology usage in classrooms. The following section presents the improvement in equipment acquisition, in educational technology standards, and in national plans. Furthermore, issues such as teachers' perceived preparedness and other barriers to effective technology usage are discussed. Eventually, evolving improvement in technology integration could lead to the transformation of instruction for the better.

Availability, standards, and national plans

With the development of technology, expenditures on equipment acquisition have increased in education. Hart, et al. (2002) identified two main reasons people want to bring computers and Internet connectivity into classrooms. First, people believe that technology provides more opportunities to promote student-centered learning and to engage students in higher-order thinking activities. Second, students are expected to be well-prepared for future postsecondary study, and the labor markets demand skills in technology usage. As a result, expenditures for acquiring equipment for schools have increased steadily.

Improvement resulting from this investment can be calibrated in two ways: the ratio of students to computer, and the rate of Internet connectivity. The national average ratio of students to computers in public schools was 19.2 in 1992 (Meyer, 2001), 10.1 in 1995, and close to 4 around 2000 (Meyer, 2001; Skinner, 2002). In 1994, the percentage of public schools accessing the Internet was 35%, and only 3% of public classrooms connected to the Internet. In 2003, the Internet connectivity rate of public schools became 100%, and classroom connectivity rate increased to 93%. Moreover, the percentage of broadband connections had increased to 95%, and the ratio of students to instructional computers with Internet access was 4.4 (Cattagni & Farris, 2001; Kleiner & Farris, 2002; Kleiner, Lewis, & Greene, 2003; Parsad & Greene, 2005; Smerdon et al., 2000; Williams, 2000). Table 2.1 illustrates the improvement.

In addition to the expenditures on equipment acquisition, providing explicit standards governing technology usage in classrooms promotes technology integration in education. In 1998, the International Society for Technology in Education (ISTE) published their National Educational Technology Standards (NETS) for Students (ISTE, 1998). In 2000, NETS for Teachers were released (ISTE, 2000), and so were NETS for Administrators in 2001 (ISTE, 2001). Before May 19, 2004, 49 states had adopted, adapted, aligned with, or referenced at least one set of standards in their state technology plans, certification, licensure, curriculum plans, assessment plans, or other official state documents (ISTE, 2004). The standards for students and for teachers suggest how technology can be integrated with instruction to establish learning environments which promote active inquiry and problem-solving, higher-order learning skills, collaboration, and lifelong learning. The standards share many concepts of technology integration mentioned in the previous sections (see Appendix A).

Table 2.1 Improvement of Technology Equipment in U.S. Public Schools

Percent of public schools with Internet access									
1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
35	50	65	78	89	95	98	99	99	100
Percent of public school instructional rooms with Internet access									
1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
3	8	14	27	51	64	77	87	92	93
Ratio of students to instructional computers with Internet access in public schools									
1998	1999	2000	2001	2002	2003				
12.1	9.1	6.6	5.4	4.8	4.4				
Percent of schools with Internet access using broadband connections									
2000	2001	2002	2003						
80	85	94	95						

Data source: U.S. Department of Education, National Center for Education Statistics, Fast Response Survey System (Cattagni & Farris, 2001; Kleiner & Farris, 2002; Kleiner et al., 2003; Parsad & Greene, 2005; Williams, 2000).

Furthermore, after consulting with a wide range of stakeholders including educators, researchers, policymakers, students, parents, leaders in higher education, industry, and elsewhere, the U.S. Department of Education (2000) promoted five National Educational Technology Goals. First, students and teachers will have access to information technology in their classrooms, schools, communities and homes. Second, all teachers will use technology effectively to help students achieve high academic standards. Third, all students will have technology and information literacy skills. Fourth, research and evaluation will improve the next generation of technology applications for teaching and learning. Finally, digital content and networked applications will transform teaching and learning. It was believed that taking advantages of the affordability and capabilities of technology would enhance learning and improve student achievement for all students.

Issues of technology integration

Although data show impressive improvement in the availability of equipment and in national plans for encouraging technology integration, research findings indicate many pre-service and in-service teachers feel unprepared for integrating technology with their instruction. Moreover, the frequency and methods of technology usage in classrooms illustrate very little improvement in fostering students' higher-order thinking and problem-solving with technology. Various barriers and factors influence the willingness of teachers to use technology.

Preparedness

Regarding the perceived preparedness for technology integration in education, the U.S. Congress' Office of Technology Assessment (OTA) (1995) reported that only three percent of teacher education graduates felt "very well prepared" to use technology in the classroom. Many teachers may know how to do word processing or search the Internet, but they still do not understand how to truly integrate technology into their teaching (Schwab & Foa, 2001). The Web-Based Education Commission (2000) also found while younger teachers might have more basic technology skills than their older colleagues, they frequently did not know how to apply these skills to teaching. Similarly, Russell, Bebell, O'Dwyer, & O'Connor (2003) found young teachers use technology less often for delivering instruction or engaging their students in learning activities than experienced teachers although young teachers are usually more confident and comfortable with their use of technology. In fact, most new teachers graduate from teacher preparation institutions with limited knowledge about how technology can be used in their professional practice (Hart, et al., 2002). In addition to the anxiety of being new teachers, they may also have concerns about how to benefit from using technology in their teaching (Hazzan, 2002-2003). The National Council for Accreditation of Teacher

Education (NCATE, 1997) emphasized that to prepare for the 21st-century classroom, a teacher education program needs a vision of fully integrated technology.

Likewise, President's Committee of Advisors on Science and Technology, Panel on Educational Technology (1997) stated that K-12 teachers received little technical, pedagogic or administrative support for conducting activities using technology, and that few colleges of education adequately prepared their graduates to use information technologies in their future teaching. The panel stressed that to achieve effective technology integration, teachers need to select appropriate software, create new lesson plans, use innovative strategies to resolve problems, and develop appropriate assessment methods. However, only about 15 percent of the typical computer budget was spent on professional development, and most professional development focused on training teachers simply to operate a computer rather than to more fully use computers to enhance teaching and learning. The panel also reported that many teachers did not have adequate access to technological and pedagogical support on an ongoing basis. Therefore, the panel made several recommendations, including focusing on learning with technology rather than merely about technology, emphasizing content and pedagogy rather than just hardware, and paying special attention to ongoing professional development.

Still, the National Center for Educational Statistics (NCES) (1999) found that less than 20% of teachers felt very well prepared to integrate technology with their instruction. A report conducted by the National Council for Educational Statistics (Smerdon et al., 2000) sampled 2,019 full-time teachers in the United States (1,016 elementary school teachers and 1,003 secondary/combined school teachers) to investigate teachers' technology usage. The findings showed many teachers were comfortable using computers for personal productivity, but at least two-thirds of the teachers felt unprepared to integrate technology into instruction. Only half of the teachers reported that they used technology for instruction and when they used it, it was poorly integrated with other classroom activities.

Frequency and ways of technology usage

A nationwide survey, Teaching, Learning, and Computing (TLC), involved more than 4000 4th-12th grade teachers in over 1100 school across the U.S. The survey asked them to describe their educational philosophies and characteristics of teaching practices, their uses of computers in teaching, and the school environments (Becker, 2000; Becker, Ravitz, & Wong, 1999). The researchers found only one-fourth of teachers gave students frequent opportunities to use educational technology during class time (Becker et al., 1999). In general, word processing, CD-ROM reference, and Internet searches were the most widespread applications (Becker, 2000; Becker et al., 1999). TLC findings also indicated that 47% of the teachers who were Tech/Ed Grant winners reported they had their students use the Internet in class at least 16 minutes per week. Sixty percent of the grant-winning teachers used the Internet for their teaching activities at least 16 minutes per week (Soloway, Becker, Norris, & Topp, 2000). It is reasonable to assume that most teachers who were not grant winners spent less time using the Internet in their classroom.

In 2000, the Consortium on Chicago School Research conducted a study on the instructional use of computers and the Internet in Chicago public schools (Hart, et al., 2002). The researchers obtained information from 11,214 teachers (8,572 elementary and 2,642 high school teachers) and 87,832 students in grades six through ten. They found 31 percent of the teachers either did not use technology at all or seldom used it. At most, these teachers used technology once a semester to create instructional materials or gather information for lesson plans. Fifty-two percent of the teachers were limited users who employed technology for basic tasks up to once a week, accessed model lesson plans and teaching practices up to once or twice a month, and created multimedia presentations occasionally. About 17 percent of the teachers were intensive users. In terms of integrating technology into student assignments, 6 percent of the teachers were categorized as “highly integrated,” assigning students uncommon tasks such as demonstrations, creating web pages and computer programming, as well as more common tasks. The “integrated” teachers (11 percent) assigning basic tasks such as word processing and Internet research weekly, and more advanced tasks such as analyzing/graphing data or creating presentations at least once per semester. Fifty-five percent of the teachers were modest or limited teachers, and they assigned word processing or Internet research from once or twice a semester to once or twice a month. Finally, 29 percent of the teachers did not assign technology work at all.

A national nonprofit organization called NetDay (2001) also reported on the results of another survey. More than 84% of the teachers believed the quality of education was improved by computers and the Internet, and 75% of the teachers thought that the Internet was an important tool for finding new resources to meet new standards. However, two-thirds of those teachers did not think they integrated the Internet with their instruction well, and 76% of them did not feel pressured to use the Internet in their instruction. Moreover, 48% of the teachers agreed the Internet was an important tool for teaching, but half or more used the Internet at school for less than 30 minutes a day. The findings indicated that helping teachers move beyond using the Internet as a research tool was a challenge.

An online survey of 11,132 K-12 teachers from 1,885 schools conducted by NetDay (2004) yielded more encouraging results. Eighty-seven percent of the teachers indicated technology was important or very important to their work as a teacher. Seventy-five percent of teachers felt that their school-based work conditions encouraged their use of technology, and 78% of them considered technology an asset in meeting state and federal accountability requirements. These teachers reported they were using technology devices and web tools regularly to meet their school-based responsibilities. Seventy-one percent of the teachers felt comfortable asking their students for technical support in the classroom, 22% indicated they always included Internet materials in their instruction, and 53% included it sometimes. However, respondents of the survey could be more enthusiastic about technology usage on average because the data were from a self-selected convenience sampling of online users.

Cuban (2003) suggested even though the computer was extensively regarded as a learning tool, most teachers did not include this tool in their daily teaching repertoire. Not only are most teachers and students rare users or nonusers of technology, but also technology is usually integrated in ways to accommodate existing teacher-centered instruction if teachers decide to implement the innovation of technology integration (Cuban et al., 2001; Hodas, 1993; Tyack & Cuban, 1995). Large-scale studies indicate word processing, Internet research, and practice drills were still the most commonly used technology applications (Hart et al., 2002; Niederhauser & Stoddart, 2001; Smerdon et al., 2000). Schwab & Foa (2001) argued many thousands of teachers do not know how to incorporate technology into their teaching even though they know how to use word processing and search information online. They stressed the importance of scaling up effective training to help nationwide teachers change their habits and integrate new technologies with their instruction in meaningful ways rather than simply training teachers for sending e-mail, searching information online, doing PowerPoint presentation or creating Web pages.

A study conducted by Barron, Kemker, Harmes, & Kalaydjian (2003) surveyed the largest school district on the technology usage of 2,156 teachers, and about 50% of surveyed teachers reported they used technology as a classroom communication tool.

Twenty to forty percent of these teachers reported they used technology for productivity research or problem solving. The results did not include the frequency of the teachers' technology usage but, obviously, technology was not widely used for active inquiry or problem solving by students. Furthermore, spending more class time in using various technology applications for teaching or learning does not necessarily lead to instructional transformation. Hence, while improving equipment and encouraging teachers to increase applications and frequency of technology usage, more attention should be paid to how technology can be integrated to improve current teaching and learning and how teachers will be willing to undertake this transformation.

Barriers to technology integration

In 1999 the most frequently reported barriers to using computers and the Internet for instruction by public school teachers were lack of release time for teachers to learn, lack of time in the daily schedule for students to use computers in class, and not enough computers (82%, 80%, and 78 % of the teachers, respectively). Seventy-one percent of the teachers reported lack of good instructional software, and 58 % reported the difficulty of accessing the Internet. Nearly two-thirds of the teachers reported barriers including lack of support regarding ways to integrate telecommunication into the curriculum, lack of technical support or advice, inadequate training opportunities, and inadequate equipment (68%, 64%, 67%, and 66%, respectively). Fifty-nine percent of the teachers were concerned about students' access to inappropriate materials; lack of administrative support was a less frequently reported barrier (43%) (Smerdon et al., 2000).

The survey conducted by NetDay (2001) indicated that 78% of the teachers reported lack of time as the number one reason for not using the Internet. Forty-six to fifty percent of the teachers selected lack of equipment, speed of access, or lack of technical support as barriers to using online resources. In addition, 32% of the teachers reported lack of leadership from the principal or administrators as a reason for not using the Internet. In the 2004 NetDay survey, respondents reported lack of time in the school day as the most serious obstacle to technology usage. Other obstacles included not enough computers, inadequate equipment, slow access to the Internet, and school filters and firewalls (NetDay, 2004).

Brickerner (1995) categorized obstacles to technology usage in education into first- and second-order barriers. Brickerner described the first-order barriers to technology integration as extrinsic to teachers which include factors such as lack of access to computers and software, insufficient time to plan instruction, and inadequate technical and administrative support. The second-order barriers are intrinsic to teachers and include beliefs about teaching, beliefs about computers, established classroom practices, and unwillingness to change. Many first-order barriers may be resolved by providing additional resources and training, but overcoming second-order barriers requires confronting individuals' beliefs and the routines of organizational practice (Brickerner, 1995). Factors hindering a fundamental change are usually second-order barriers, perhaps because they are less tangible, more personal, and more deeply rooted (Ertmer, 1999). Ertmer (1999) extended Brinkerner's arguments and indicated various barriers continually work together to affect the results of technology integration. Integrating technology into classrooms is a multifaceted challenge, and addressing first- and second-order barriers simultaneously can be more effective.

Transformation of technology usage

According to the TLC findings (Becker, 2000; Becker & Ravitz, 1999), the characteristics of teachers who are frequent computer and Internet users seem to be: (a) more willing to discuss a subject in which they lack expertise and feeling comfortable being taught by students; (b) conducting multiple activities simultaneously during class time; (c) assigning students long and complex projects for investigation, and (d) allowing students more choice in selecting their tasks and the materials and resources for completing the tasks. Becker & Ravitz (1999) proposed that technology has an emancipating effect on teachers who believe in project-based teaching and other teaching practices compatible with constructivist concepts. Teachers who prefer more student-centered instructional approaches such as encouraging students to conduct their own inquiries or projects, engaging students in collaborative activities, and assuming the role of facilitator or coach, are usually the most enthusiastic technology users (OTA, 1995).

Transforming teacher-centered instruction into approaches more compatible with concepts of constructivism requires time and effort, and the transformation evolves over time (CTGV, 1998). For instance, the researchers of the Apple Classroom of Tomorrow (ACOT) project presented their ten-year research findings and defined five stages of technology integration which the participant teachers went through (Apple Computer, Inc., 1995; Sandholtz, Ringstaff, & Dwyer, 1991, 1997). At the Entry Stage, teachers with little or no experience with educational technology felt different degrees of trepidation and excitement. They struggled to establish the physical environment. Teachers could find themselves encountering first-year-teacher problems such as discipline, resource management and personal frustration. In the following Adoption Stage, teachers began to teach students how to use technology and adopted new technology to support traditional instruction occasionally. Whole-group lectures, recitations, and individual seatwork remained the main activities in the classroom. Technology was thoroughly integrated with traditional classroom practice at the third stage, Adaptation Stage. Although lecture, recitation, and seatwork were still the main forms of learning, students spent 30-40 % of class time using word processors, databases, graphic programs, or CAI software. Students used the applications to produce more work and at a faster rate. At the fourth stage, Appropriation Stage, teachers revealed a change in their beliefs about technology usage. This was a critical stage for teachers to develop creative strategies to engage students in collaborative and meaningful learning. There was more team teaching, interdisciplinary project-based instruction, and self-paced instruction at this stage. Finally, at the Invention Stage, teachers were more likely to view learning as an active, creative, and socially interactive process. Their pedagogical beliefs moved toward more constructivism, and they discovered new ways to use technology in implementing an integrated curriculum, balanced and strategic use of direct and project-based teaching, and alternative assessment methods (Apple Computer, Inc., 1995; Sandholtz et al., 1991, 1997).

Rogers (1995) also outlined a five-stage model of innovation diffusion (i.e. Knowledge Stage, Persuasion Stage, Decision Stage, Implementation Stage, and Confirmation Stage). Similarly, King (2002) suggested there are four transitions of emotion and learning that teachers usually experience in technology integration (i.e. fear and uncertainty, testing and exploration, affirming and connecting, and new perspectives). In the later stages of both models, technology integration shifts toward student-directed learning and involves students in conducting complex tasks to master content and higher-order thinking skills. Teachers begin to invent new ways to apply technology and collaborate with other teachers to undertake interdisciplinary projects.

Unfortunately, it is commonly acknowledged that putting computers and Internet connections into classrooms does not guarantee effective and creative technology integration nor does it transform teaching practices into student-centered or constructivist pedagogy (Becker 2000; Becker & Riel, 1999; Cuban, 2001; Hokanson & Hooper, 2004; Netday, 2001; Windschitl & Sahl, 2002). Moreover, teachers who successfully combine technology with more constructivist instruction may employ technology as the means for the change they already decided to make (Dexter, Anderson, & Becker, 1999; Cuban, 2001; Cuban et al., 2001).

Teacher belief and technology integration

A crucial factor for successful technology integration is the teacher (e.g., Becker & Riel, 1999; Bitner & Bitner, 2002; Loveless, DeVoogd, & Bohlin, 2001; Romano, 2003; Zhao & Cziko, 2001) because it is the teacher rather than external educational agenda or requirements who directly decides the instruction which takes place behind the classroom door (Hodas, 1993; Tyack, & Cuban, 1995). Studies indicate teacher beliefs play a critical role in transforming their instruction into more constructivist practice with technology (e.g., Bitner, & Bitner, 2002; Dexter et al., 1999; Ertmer, 1999, 2005; Fisher, Dwyer, & Yocam, 1996; Niederhauser & Stoddart, 2001; Ravitz, Becker, & Wong, 2000; Sandholtz, Ringstaff, & Dwyer, 1991, 1997; Windschitl & Sahl, 2002). Therefore, understanding teacher beliefs and the relationships between beliefs and practices should help to shed light on how teachers make decisions about their technology integration.

Conceptualization and characteristics of teacher beliefs

In a classroom, the teacher perceives and defines a teaching situation, makes judgments and decisions, and then takes actions for the particular situation. Therefore, researchers should strive to understand how teachers go about making judgments and decisions which affect their practices (Clark & Yinger, 1979; Woods, 1996). Furthermore, to improve teacher preparation and teaching practice, more attention should be paid to teacher beliefs because these beliefs profoundly influence the decision-making processes and teaching practices (e.g., Borko & Putnam, 1996; Borko, Cone, Russo, & Shavelson, 1979; Kagan, 1992; Nespor, 1987; Pajares, 1992; Richardson, 1994; Woods, 1996). Based on their beliefs about teaching, educational goals, or student learning, teachers choose specific strategies and materials from their repertories to tackle particular situations. Their beliefs help decide what problems to focus on and how to solve the problems (Borko& Putnam, 1996; Borko et al., 1979; Nespor, 1987).

Although study on teacher beliefs has great potential for providing educational communities with unprecedented insights, it faces the difficulty of being short on clear and commonly accepted definitions, conceptualizations, and understandings of beliefs and belief structures (Pajares, 1992). Different terms were used to indicate a similar concept (Kagan, 1992; Pajares, 1992; Richardson, 1994), and the list of terms seems to grow endless: attitudes, values, judgments, axioms, opinions, ideology, perceptions, conceptions, conceptual systems, preconceptions, dispositions, implicit theories, explicit theories, personal theories, internal mental processes, action strategies, rules of practice, practical principles, perspectives, repertories of understanding, and social strategy (Pajares, 1992, p. 309). The difficulty in defining teacher beliefs concentrates on the difficulty and ambiguity of differentiating beliefs from knowledge (Calderhead, 1996; Pajares, 1992; Richardson, 1994). For instance, Rokeach (1968) suggested all beliefs include a cognitive component representing knowledge, an affective component arousing emotions, and a behavioral component guiding actions. Therefore, knowledge is regarded as a component of belief. However, while acknowledging beliefs do affect teacher thinking, Roehler, Duffy, Herrmann, Conley, and Johnson (1988, cited by Pajares, 1992; Richardson, 1996) argued knowledge structures are the main force driving the teacher's behavior in a classroom. They proposed that knowledge is fluid in different contexts and open to integrating new experiences but belief is surrounded by emotion and is too static to change. Therefore, they prioritized knowledge over beliefs. Kagan (1990) decided to use belief and knowledge interchangeably because much evidence shows a teacher's knowledge is largely expressed in highly subjective terms.

Although knowledge and beliefs are "inextricably intertwined" (Pajares, 1992, p.325), Nespor (1987) suggested beliefs are distinguished from knowledge by four perspectives. First, an individual's beliefs usually consist of presumption about the existence or nonexistence of entities. Second, unlike knowledge which usually represents factual propositions as either true or false, beliefs usually include representations of alternative realities. Third, the construction of belief systems is heavily influenced by the affective and evaluative components. Fourth, knowledge systems are mainly stored in semantic networks but beliefs systems are stored episodically. Therefore, beliefs are usually shaped by personal experiences and knowledge transmitted from cultures or institutions (e.g. folklore). Because of the characteristics of beliefs, the propositions or concepts of belief systems do not require consensus by belief-holders or outsiders and beliefs are usually disputable. Also, beliefs systems can be viewed as loosely-bounded, which have no clear logical rules connecting these beliefs to events or situations in real life. The connections can be formed from personal, episodic and emotional experiences.

Green (1971, cited by Mewborn, 2002) described the structure of belief systems including the relationship between beliefs, the strength of beliefs, and how relevant beliefs cluster. Belief systems are organized by primary beliefs and beliefs derived from other beliefs. A primary belief is too self-evident to explain, while a derivative belief is related to other beliefs so it can be explained by using another belief as evidence. Similar to Rokeach's (1968) description, Green argued some beliefs are more central to the belief systems (i.e. core beliefs) and resistant to change because they are held with "passionate conviction" (p.53). Meanwhile, peripheral beliefs are held with less psychological strength and further from the belief systems. With examination and discussion, peripheral beliefs are easier to change. Consistent beliefs are held in the same cluster, but people may hold conflicting beliefs without noticing the conflict as long as the conflicting beliefs are held in separated clusters and not compared with one another. To be open to change, it is favorable to form belief systems consisting of more evidential beliefs which are based on evidence and reasons. Also, reducing the numbers of core beliefs and belief clusters and increasing the connections among clusters can eliminate conflict among beliefs and allow belief systems to be more flexible for changes.

Pajares (1992) argued people have beliefs about everything and conceptualizing a belief system is to recognize that the belief system contains various beliefs connecting to one another. Furthermore, clusters of beliefs focusing on a construct form an attitude (Rokeach, 1968). Teachers' attitudes about education including schooling, teaching, learning and students are usually represented as teacher beliefs (Pajares, 1992). However, the construct of educational beliefs may still be too general for research purposes so Ertmer (2005) followed the recommendation of Pajares (1992) to specify her investigation of teachers' educational beliefs about teaching and learning which is also referred as pedagogical beliefs. As proposed by Ertmer (2005), this study focuses on teachers' pedagogical beliefs and their beliefs about how technology can facilitate the process of putting pedagogical beliefs into practices. Through understanding of these beliefs and their relationships, some insights can be uncovered to inform future research and practices regarding teachers' technology usage.

Beliefs, practices, and teacher change

Although Kagan (1992) concluded there is very limited evidence showing exactly how teacher beliefs change, research indicates teacher beliefs are derived from prior experiences (Goodman, 1988; Kagan, 1990; Richardson, 1996). In fact, because of the aforementioned affective, evaluative, and episodic characteristics of belief systems, existing beliefs serve as a filter to influence how new events or situations are interpreted (Borko et al., 2000; Borko & Putnam, 1996; Cohen & Ball, 1990a, 1990b; Pajares, 1992).

Indeed, prior experiences were incorporated into a person's belief systems through which this person reacts to new situations. For example, Cohen & Ball (1990a, 1990b) presented how teachers reacted to a new educational policy. Although the goal of the reform was to substantially change the teachers' instruction through requiring them to adopt new instructional approaches and materials, many teachers interpreted the requirements based on their existing beliefs. Therefore, their instruction still presented the influence of their beliefs. Richardson (1996) suggested three types of experiences may shape the knowledge and beliefs of teaching: personal experience, experience with schooling and instruction, and experience with formal knowledge.

It is reasonable to speculate that teacher beliefs are closely related to teacher practices. However, the order of belief-change and practice-change remains uncertain. Teachers may change their beliefs before or after they change their practices. Richardson (1994) argued belief-change and practice-change are interactive and the process of teacher change may start with either. For example, Borko et al. (2000) described how two teachers reacted to the process of changing instructional strategies. One teacher decided to conduct certain new activities consistent with her changed beliefs. Meanwhile, the proposed new activities challenged the other teacher's beliefs and the inconsistency resulted in her belief change. Fullan (2001) raised a similar argument that the process of changing in behavior and beliefs is reciprocal and ongoing. Belief change influences how well the teacher does in a classroom, and changes in practices provide the teacher with necessary experiences to develop new thinking and understanding. Also, research indicates teachers' beliefs are not necessarily consistent with their practices (e.g., Enyedy & Goldberg, 2004; Fang, 1996; Richardson, Anders, Tidwell, & Lloyd, 1991; Warfield, Wood, & Lehman, 2005). For instance, Richardson et al. (1991) explained a teacher's practices did not reflect her beliefs because the teacher was undergoing the process of changing beliefs and practices.

Yet, changing teacher beliefs is never an easy task. While discussing educational innovation, Fullan (2001) advocated significant innovation should be multidimensional and at least three components of change are involved: (1) new or revised materials and resources such as new curriculum materials or technologies, (2) new teaching approaches, and (3) belief change. Acquiring new materials and resources may be the most visible and easiest change to accomplish, but changing teaching approaches presents a bigger challenge because new skills and knowledge to conduct new strategies and activities are needed. Eventually, changing teacher beliefs is the most difficult task because teachers' core values need to be made explicit, to be understood, and to be confronted.

Research indicates some beliefs are especially resistant to change because they are more central in the belief system and connect to more beliefs. The longer a belief has been incorporated into the belief systems, the more difficult it is to be changed. These beliefs tend to become the believers' core values and are self-definitive of a person (Pajares, 1992; Rokeach, 1968). Therefore, beliefs derived from personal experiences are especially resistant to change because they are usually formed earlier in life. Moreover, existing beliefs influence future perceptions and information processing and therefore are strengthened again and again. While facing contradictory evidence, individuals may still hold onto existing beliefs or simply make some superficial change (Nespor, 1987; Pajares, 1992). Therefore, when implementing new materials or instructional strategies, teachers may in reality retain their beliefs and mistakenly think they are undertaking innovations (Cooney, 1999; Cohen & Ball, 1990a, 1990b; Pajares, 1992).

Even though teachers are willing to change their own pedagogical beliefs, they may still struggle with conflicting beliefs, goals, knowledge, and constraints held by colleagues, students, parents, policy makers, and other stake holders (Enyedy & Goldberg, 2004). Contextual factors in schools and classrooms significantly impact the process of changing teachers' beliefs and knowledge (Richardson, 1996). As described by Doyle (1977), complex classroom life involves various activities and processes with different purposes. Many events occur simultaneously or even haphazardly, and these events usually demand the teacher's immediate attention. To manage this complexity, teachers may develop different coping strategies which may not be inconsistent with their own beliefs (Davis, Konopak, & Readence, 1993).

Tabachnick & Zeichner (2003) suggested consistency of teacher beliefs and practices is a consequence of an ongoing negotiation process with which an individual teacher resolves conflict between organizational supports and constraints. Hence, teachers do not always make decisions based solely on their pedagogical beliefs. To understand and change a teacher's practice, the teacher's beliefs and knowledge, the context surrounding the teacher, and others factors affecting the teacher's decision-making process should all be primary concerns (Calderhead, 1987; Fullan, 2001; Woods, 1996). Furthermore, Woods (1996) argued finding and categorizing all contextual factors could not uncover teachers' decision-making process because all elements related to the process are interactive dynamically. Therefore, a teacher never simply changes one specific belief because it is definitely related to other beliefs and contextual factors. The relationships among various beliefs and contextual factors should be the focus of research on teacher beliefs and practices.

Teacher beliefs, contextual factors and technology usage

Since teacher beliefs are closely related to teacher practices, teachers' technology usage is naturally influenced by their pedagogical beliefs. The arguments of Zhao & Cziko (2001) highlight the important role teacher beliefs play in technology integration. For teachers to use technology, they must believe: (1) technology can help them achieve higher-level goals more effectively; (2) no other more important goals will be disturbed by the technology usage; and (3) they have adequate ability and sufficient resources to use technology. They further explained that teachers may be unwilling to adopt technology if the promoted usage is inconsistent with their existing beliefs or practices. Although various factors may influence teachers' technology integration, teachers' perceptions or beliefs serve as a filter to decide priorities of different factors. Certain factors can be regarded as more close to the core beliefs. Therefore, what types of applications and to what degree technology will be integrated into a classroom depend on the teacher's perception (Zhao & Frank, 2003). Technology is usually used in ways to meet teachers' instant needs, to conform to their cost-benefit concerns, and to support the current practices (Cuban et al., 2001; Hodas, 1993; Zhao & Frank, 2003).

Often, the proposed technology usage requires teachers to change their pedagogical beliefs and teaching approaches (Hoban, 2002; Hokanson & Hooper, 2004; Loveless et al., 2001; Sandholtz et al., 1991, 1997), and these changes may be against their higher-order goals or maybe too demanding to undertake so teachers may resist the innovations (Zhao & Cziko, 2001). Richardson et al. (1991) argued teacher beliefs need to be consistent with the theoretical foundations of practice. Conducting a practice without a congruent theory may result in unsatisfactory implementation or even no implementation. The study findings of Zhao, Pugh, Sheldon, & Byers (2002) confirmed that incompatibility between teachers' pedagogical beliefs and their technology usage can lead to unsuccessful results. In addition, integrating technology with instruction usually adds additional workload to already stressed teachers (Sandholtz et al., 1997). It also requires teachers to cope with novelty and uncertainty. For teachers, discarding their current routines and practices and changing their beliefs may put them into a very vulnerable situation (Olson & Eaton, 1987). It is no wonder they are reluctant to undertake the transformation.

Most teachers--veterans or novices, have very limited understanding and experience about how technology should be integrated to facilitate teaching and learning. While attempting to incorporate technology to their instruction, these teachers tend to refer to their existing beliefs and prior experiences. Their early perceptions can influence developing beliefs about technology integration and the following practices (Ertmer, 2005). Hence, teacher beliefs should be taken into account at different stages of technology integration. Although teacher beliefs are recognized as a crucial factor in technology integration, various contextual factors may cause the inconsistency between expressed pedagogical beliefs and implemented practices with technology (Ertmer, 2005). Numerous studies address various factors and barriers affecting technology integration (e.g., Bitner & Bitner, 2002; Bullock, 2004; Cuban, 2001; Cuban et al., 2001; David, 1996; Dexter et al., 1999; Doering et al., 2003; Hart et al., 2002; King, 2002; Mouza, 2002-2003; OTA, 1995; Pfundstein, 2003; Strudler & Wetzel, 1999; Tyack & Cuban, 1995). However, as Zhao et al. (2002) argued, the theoretical and practical values of such studies will be limited if they do not clarify the characteristics of each factor, the applied context of the factors, and the relationships among different factors.

Blumenfeld et al. (2000) and Hung & Koh (2004) shared a similar viewpoint. Blumenfeld et al. (2000) developed a systematic framework which consists of three dimensions--culture, capability, and infrastructure--to evaluate how to achieve successful reform. Hung & Koh (2004) proposed four dimensions that would impact technology integration: school structures, classroom dynamics, teacher beliefs, and student behaviors. Both research teams considered different factors as interrelated and argued that simply addressing isolated issues will not lead to successful integration and transformation. Therefore, this study not only investigates the influence of teacher beliefs on technology integration but also focuses on the relationships among the beliefs and other contextual factors.

SITUATIONS IN TAIWAN

This study examines how Taiwanese high school teachers' pedagogical beliefs and beliefs about the potential of technology integration affect their decisions of implementing technology integration. The contextual factors surrounding the teachers interplay to affect their beliefs and practices. Hence, the following sections serve as an overview of the educational environment, educational policies, and technology usage in Taiwan. The general description illustrates a broader context in which the teachers are influenced and, at the same time, make their own contribution to the transformation of education with technology.

A brief history

Taiwan is located about 100 miles from the southeast coast of Mainland China. Currently, there are twenty-three million people living on this 13,900-square-mile island. Taiwan is the second most densely populated nation in the world. It has only limited natural resources, and its economy is dependent on bilateral trade with other countries. In 1912, the Chinese Nationalist Party (also called Kuomintang, KMT) overthrew the Qing Empire and established the Republic of China (ROC). After World War II, Japan ended its colonization in Taiwan and returned Taiwan to the ROC. In 1949, the leader of KMT, Chiang Kai-Shek, moved the Central Government to Taiwan after the Communist Party won the Civil War and took over Mainland China (Huang, 1999; Huang 2001; Law, 2002; Pan & Yu, 1999). In 1949, the KMT enacted Martial Law to suspend the constitutional rights of people so the government could maintain the stability of its leadership (Law, 2002).

To eliminate the influence of Japanese colonialism and to accelerate the acceptance of Chinese nationality of the Taiwanese, the only language allowed in school was Mandarin. The school curricula overwhelmingly emphasized Chinese literature, Chinese history and Chinese geography (Huang, 2001; Law, 2002). To transmit the ideologies favoring the KMT, the Ministry of Education prescribed the curriculum and textbooks. The National Institute of Compilation and Translation (NICT) was in charge of writing and designing the textbooks for elementary and secondary schools. Confucianism was emphasized in the education system, because the KMT government wanted to preserve Chinese culture and Confucianism which had been the most influential philosophical system in Chinese culture. Moreover, the Confucian values such as loyalty, filial piety, conformity, industriousness, and cooperation aligned with the ideologies the KMT government proclaimed (Huang, 2001; Pan & Yu, 1999).

Viewing higher education as a potential threat to the stability of its leadership, the KMT government constrained higher education in several ways (Huang, 1999; Yang, 2001). For example, only the Ministry of Education had the power to establish institutes and departments, appoint college/university presidents, allocate funds, design the college curricula, and screen the publication of academic research (Mok, 2000). A highly selective examination was used to filter students, and only a small number of academically competent students could obtain admission to prestigious universities (Pan

& Yu, 1999). In addition, only specific public institutions (i.e. the so-called Normal College or Normal University) were allowed to provide teacher education (Yang, 2001).

In the years since the KMT fled to Taiwan, many countries have established relations with the People's Republic of China (PRC) and severed diplomatic relations with Taiwan. Nowadays, Taiwan has official diplomatic relations with very few countries. Taiwan has been unable to participate in many international organizations and is not recognized as a nation by many in the international community (Huang, 2001; Law, 2002). Despite this harsh situation, Taiwan has made impressive economic achievements. Education is commonly considered an important factor in the country's achievement (Liu & Armer; 1993; Pan &Yu, 1999; Wu, 1998). In order to improve the general capability of the people and to meet the needs of labor-intensive industries, the KMT government extended compulsory education from six to nine years, with a six-year elementary school and three-year junior high school.

In the 1970s and 1980s, economic demand shifted to technology-intensive and capital-intensive industries, so the government established more vocational-technical junior colleges. Later, additional four-year technical institutes were set up to provide an even higher-level manpower (Pan & Yu, 1999; Wu, 1998). In 1951, the education expenditure of Taiwan was about 1.7% of GNP and 9.93% of the total government expenditure. In 1998, the education expenditure was 6.41% of GNP and 18.54% of the total government expenditure (Mok, 2000). These figures show the government viewed compulsory education as a priority (Pan & Yu, 1999). In addition, the KMT government used favorable policies to provide pre-service and in-service teachers with all kinds of benefits. The emphasis of Confucianism in education also reinforced the social status of teachers. In general, teachers in Taiwan are highly respected and are satisfied with their work and lives (Fwu & Wang, 2002a; 2002b).

Educational reform since 1994

Taiwan has been transforming into a more democratic society. Since the repeal of Martial Law in 1987, Taiwanese resumed the rights and freedoms protected by the constitution, such as freedom of speech, assembly and publication (Huang, 2001). After the lifting of Martial Law, the Ministry of Education was more willing to undertake reforms in education. However, these gradual reforms did not satisfy the public. The central government still decided the educational budget, the appointment of university presidents and public school principals, and the standards for curricula and textbooks. The public started pressuring the government to institute education reforms (Pan & Yu, 1999). Among the many unpopular regulations in education, joint entrance examinations for senior high schools, vocational-technical schools and colleges were heavily criticized. Using tests to select competent people for civil service was a tradition in Chinese history, and the same concept was applied to the education system in Taiwan. Based on Confucianism, the Taiwanese value scholarship and respect intellectuals, so most parents want their children to pursue higher education (Huang, 2001; Pan & Yu, 1999; Yang, 2004). Most teachers focused exclusively on the content knowledge which might be tested, and secondary students were under enormous pressure to perform well in the high-stakes testing. It was common that secondary school students spent much of their free time in cram schools, and their parents had to spend much money on these schools. Another serious problem was that only a few students could be successful and the learning of many students was actually neglected (Lee, 1996).

Therefore, different civil organizations were formed to push the government to create an appropriate educational system for students. On April 10, 1994, about 10,000 individuals attended a demonstration and demanded that the government reform its educational system. They expressed four demands: (1) to have smaller-sized schools and classes; (2) to greatly increase the number of high schools and colleges; (3) to draft a "Basic Education Law;" and (4) to modernize education (Pan & Yu, 1999; Lee, 1996). To respond to these demands, the government established a Council on Education Reform (CER). The CER eventually published a report with five themes for reform: deregulating educational systems, attending to the individual needs of students, alternatives for continuing education, ensuring educational quality, and establishing a lifelong learning society (Mok, 2000). Based on the report of CER, the Ministry of Education published the Educational Report of the Republic of China in 1995 and presented five goals: (1) to relieve stress in the examination system, (2) to ensure equitable distribution of educational resources, (3) to facilitate educational liberalization, (4) to enhance educational quality, and (5) to disseminate the spirit of humanism (Lee, 1996).

To achieve those goals, the government undertook a series of new policies and arrangements. For example, different admission systems were designed to replace or improve the joint entrance examinations (Pan & Yu, 1999). Teachers and schools were given more freedom in designing and adopting appropriate curricula and textbooks (Law, 2004; Lin, 2003). Professors, teachers and researchers were given professional autonomy (Mok, 2000). Teacher education was opened to other colleges and universities (Fwu & Wang, 2002a; 2002b). However, in 2003, over 100 professors endorsed a commentary in which reform they criticized and called for the government to reconsider its educational policies. Educational policies and practices continue to evolve, and all stakeholders, including researchers, policy makers, teachers, parents, and students, are observing the transformation closely.

Technology integration in Taiwan

The Ministry of Education started conducting the Ministry's Educational Reform Action Program in 1999 (Ministry of Education, 2001a, 2002a). The program includes 12 projects covering areas such as pre-school education, elementary education, teacher training and continuing education, technological and vocational education, higher education, lifelong education, information education, and family education. An important component of this program is building the information education infrastructure. Key points of this plan include establishing computer facilities and networking environments in elementary and junior high schools, improving teaching methods, offering training programs for teachers, and obligatory one-hour computer classes every week for students above the eighth-grade in junior high school.

Since undertaking the Educational Reform Action Program, the Ministry of Education has continually reviewed and revised the educational policies to improve the establishment of technology equipment, to provide opportunities for professional development, and to encourage teachers to integrate technology in instruction (EduCities, 2001; Ministry of Education, 2001b, 2002b, 2002c, 2003, 2004, 2005). After listening to opinions from researchers, educators, administrators, and staff, the Ministry of Education announced the "Blueprint of Information Education in Elementary and Junior High Schools." In this report, the Ministry of Education suggested teachers be the driving force for guiding all citizens to become proficient in technology literacy and learning skills. Teachers would be the guide of students, and then these students would have influence on their parents. Eventually, all citizens would become computer-literate and lifelong learners. The goals of the blueprint explicitly emphasize information literacy, critical and creative thinking, effective learning strategies, active learning, collaborative learning, and lifelong learning (EduCities, 2001; Ministry of Education, 2001b).

To achieve the vision illustrated in the blueprint, the Ministry of Education has formed various plans and projects to address six main components: (a) the network and hardware infrastructure; (b) teaching materials and software; (c) students, teachers, and schools; (d) reducing the technology gap between urban and rural areas; (e) involving communities and industry; and (f) educational administration. In addition to connecting classrooms to the Internet, acquiring hardware and software, and encouraging information and resource sharing; supporting teachers implementing technology usage and providing adequate professional development are main concerns. A proposal for subsidizing seeding schools and training seeding teachers allows the Ministry of Education to spread the effects and concepts of reform. The blueprint envisioned that all teachers could integrate technology with instruction using a little over 20% of class time, and more than 600 seeding schools would be established to provide an exemplary model for neighbor schools (EduCities, 2001; Ministry of Education, 2001b, 2002c, 2003).

In 2001, the Ministry of Education reported that all public elementary and secondary schools had at least one computer lab with broadband Internet connection, and the ratio of students to computer had decreased from 36 in 1998 to 19 by 2000. Each county or city established an educational network center to provide support for the schools. Obligatory computer courses allowed elementary and secondary students to become proficient in computer literacy and operations. Various professional development programs were offered to strengthen teachers' abilities to integrate technology (Ministry of Education, 2001b). According to the Ministry of Education (2005), in 2004 teachers spent about 22.53% of the total class time to prepare for integrating technology in learning activities and about 20.82% of the total class time to create teaching materials. Moreover, there were more than 5,000 teachers participating in the training for technology-seeding teachers.

In spite of the reported improvement, many Taiwanese teachers were either unwilling or unable to integrate technology in classrooms (Lee, 2001; Ministry of Education, 2000, 2001b). When they did attempt to integrate technology with instruction, many teachers might not know how to use appropriate software and resources to promote meaningful learning (Ministry of Education, 2000, 2001b). Cheng & Chen (2004) described a commonly-held misconception of technology integration in Taiwan was that of merely using a LCD projector to do a multimedia presentation. Since this application was using technology: transmitting content from the teacher to students. Several studies investigated perceived factors or barriers affecting teachers' technology usage in Taiwan (e.g., Chen, 2003; Chen, 2004; Hsu, 2003; Wang, 2004) but no study was found focusing on how teacher beliefs and the contextual factors interact to influence technology integration. To implement the vision striven for national plans of technology integration, it is critical to know how Taiwanese teachers integrate technology in their classrooms or why they choose not to. The findings of this study should be able to provide insights for the integration of instruction with technology.

SUMMARY

According to constructivism, learners actively construct their understanding based on their prior experiences and existing knowledge structures. Through interacting with environments, tools or other people, learners gradually assimilate the shared knowledge, language, or culture. In constructivist education, the teacher designs learning activities to engage students in active problem-solving and genuine inquiry. The learning tasks are authentic and challenging, to motivate students and to confront students' misconception. Then, students need opportunities to incorporate what they have learned. Multiple viewpoints are encouraged; students can discuss, argue, and negotiate their opinions. Studies indicate learning with educational technology can foster student understanding by engaging students in higher-order thinking, self-regulated learning, and collaborative/cooperative learning.

Educational technology provides teachers and students with powerful tools to present authentic, complex, and meaningful tasks, to scaffold student learning, to allow more opportunities for reflection, feedback, and revision, and to communicate with others. As a result, there have been increasing expenditures on equipment acquisition. Moreover, commonly recognized educational technology standards for students, teachers, and administrators evolve and are adopted. In addition, national plans also provide visions for technology integration. Still, certain issues need to be addressed such as preparedness of teachers, frequency and ways of technology usage in classroom, and barriers to meaningful technology integration. Transformation of technology usage does not occur automatically, and teacher beliefs usually play a critical role in the transformation process.

In general, teacher beliefs are closely related to teaching practices, and some beliefs are more resistant to change. Therefore, for teachers to incorporate technology with their instruction in innovative ways, they may have to change their pedagogical habits and beliefs. However, requiring teachers to change their pedagogical beliefs can be a daunting task because it may involve challenging the fundamental beliefs of teachers. Moreover, different contextual factors may combine together to affect teacher beliefs and their technology usage, and the relationships among those factors and teacher beliefs need to be considered altogether. Meanwhile, the Taiwan government has established goals and undertaken a series of projects to promote teachers' technology usage. However, the technology integration in the classrooms seems unclear and infrequent, and further investigation is needed.

Chapter 3: Research Methods and Data Analysis

This study adopts the interpretivist paradigm and the qualitative case study method as the analytical framework of investigation. Considering myself as a research instrument, I highlight my perspectives in the section on data collection. Strategies of purposive sampling and data collection are illustrated. In addition, how the collected data was analyzed and managed is presented and summarized with charts. Finally, ways to ensure research quality and ethics in this study are discussed.

ANALYTICAL FRAMEWORK

The interpretivist perspective and qualitative case study methods constituted as the analytical framework of this study. The following analysis regarding the appropriateness of using this analytical framework is based on the characteristics of research focuses and study purposes.

Interpretivist perspective

According to Guba & Lincoln (1998), a paradigm can be viewed as a set of basic beliefs which represent a worldview defining the nature of the “world,” the individual’s place in the world and relationship to the world and its parts. A paradigm encompasses three elements: ontology, epistemology, and methodology. Ontology asks basic questions about the nature of reality. Epistemology inquires how we know the world and what the relationship between the inquirer and the inquired is. Methodology focuses on how we can understand the world (Denzin, & Lincoln, 1998). For example, the positivist paradigm views a tangible reality that exits “out there” and can be predicted and controlled through independently studied variables and processes which constitute the reality. The inquirer and the object of inquiry are independent of each other. Using scientific methods, the goal of inquiry is to develop causality and knowledge which can be generalized to different contexts at different times (Lincoln & Guba, 1985).

This study adopts the interpretivist perspective as its analytical framework. The interpretivism paradigm view is that realities and meanings are constructed by social actors. Particular actors in particular places at particular times create meaning out of events and phenomena through prolonged and complex processes of social interaction. To understand the meaning one must interpret it, and the inquirer should be able to explain the process of meaning construction explicitly and identify how meaning is embedded in the language and actions of social actors. The interpretation itself is a meaning-construction of the inquirer about how the studied social actors construct their meanings (Schwandt, 1998).

Howe (2001) argued interpretivists share a constructivist epistemology. Instead of viewing knowledge as accumulation of expanding organization consisting of discrete pieces acquired through passive observations, interpretivists regard knowledge as actively constructed by individuals based on cultures, history and moral or political values. Hence, realities are in the form of multiple mental constructions, and the form and content depend on the specific construction of individuals or social groups. There are multiple and possibly conflicting constructions, and these constructions are all valid. Therefore, realities or meanings are contexualized, subjective, plural, relative, and value-laden. The inquiry and the inquired are interactively linked so the realities are actually created as the inquiry proceeds. The distinction between ontology and epistemology disappears (Guba & Lincoln, 1998; Howe, 2001; Lincoln & Guba, 1985).

Qualitative case study methods

Qualitative case study methods were used to conduct this study. By studying a specific case in detail, case study researchers can obtain vivid data from various sources so they can present the complexity of a situation, investigate changes evolving over time, highlight different issues or opinions, suggests possible solutions with pros and cons, and therefore provide readers with applicability of the learned knowledge (Hoaglin et al., 1982; Merriam, 2001). As the arguments of Stake (1981) cited by Merriam (2001), compared with other research knowledge, the knowledge derived from case studies is more concrete, more contextual, more developed by reader interpretation, and based more on reference populations determined by the reader (Stake, 1981, pp.35-36). While a case study concretely illustrating a complex real-life situation and offering meanings of social actors' experiences, readers construct their own interpretation and decide how to generalize the conclusions to new situations (Hoaglin et al., 1982; Merriam, 2001, Stake, 1998). Therefore, I chose the case study method consistent with the interpretivist perspective.

However, Stake (1998) expressed that case study focuses on choosing what objects to study rather than choosing methodology. Case study researchers could use almost any kind of data, and there is no special methodology dedicated to case studies (Hoaglin et al., 1982). Although social scientists who adopt convention paradigm (i.e. positivism or post-positivism) have historically emphasized quantification, critiques to this tradition have emerged recently (Guba & Lincoln, 1998). Strict quantitative approaches focus on selecting certain variables to generalize the findings without fully considering the contexts. The general findings may not be able to be applied to individual cases. Whereas, human behaviors cannot be understood without investigating the meanings and purposes of the actors; qualitative approaches usually can provide rich explanation to human behavior. In addition, quantification-inquiry emphasizes predefined hypotheses and could therefore exclude the discovery aspect in inquiry (Guba & Lincoln, 1998). Polkinghorne (1995) indicated the primary difference between quantitative research and qualitative research is the form of the collected data. In general, there are three types of research data: short answer, numerical data and narrative data. The data that qualitative research mainly deals with is narrative data whereas quantitative research deals with numbers.

In addition, Bruner (1985) differentiated two kinds of thought: narrative and paradigmatic modes of thinking. Positivist research belongs to the paradigmatic mode, which focus on using empirical methodology to test hypotheses. The narrative mode focuses on using narratives to portray the experiences of people. He stated that paradigmatic inquiry leads to good theory, tight analysis, logical proof, and empirical discovery guided by reasoned hypotheses. On the other hand, the narrative mode of inquiry leads to good stories, gripping drama and believable historical events. According to his analyses, both modes cannot contradict or corroborate each other and both modes should be viewed as valid methods to depict the real world. Therefore, it depends what kinds of questions or phenomena we want to answer or explore in order to decide which method of inquiry is more appropriate. Eisner (1985) raised a similar viewpoint: that there are two ways in which qualitative research mode differs from the quantitative mode. One difference is that qualitative mode makes readers envision and experience the phenomena using the narrative description while quantitative mode uses numbers. The other difference is that quantitative mode prescribes the research procedure in advance while qualitative mode is more open and flexible in the research design. He said, “One approach is superior to the other, but only with respect to the nature of the problem one chooses to investigate” (p.239).

Qualitative methods were used to conduct this study because they are more able to tackle multiple realities, to expose the interaction between the investigator and respondent (or object), to describe the perspectives or biases of the investigator, and to react to many mutually-shaping influences and values (Lincoln & Guba, 1985). This study investigates how the beliefs of Taiwanese high school teachers affect their technology integration. However, researchers (e.g., Fullan, 2001; Kagan, 1990; Richardson, 1994) indicate that teacher beliefs are seldom articulated and examined. Teacher beliefs may be held unconsciously and, sometimes, teachers do not know how to describe their own beliefs or they may feel reluctant to express their unpopular beliefs. Moreover, teacher beliefs are usually contextualized and related to various factors which need to be addressed all together (Kagan, 1990). Therefore, Kangan (1990) and Pajares (1992) suggested teacher beliefs must be inferred from teachers' talk and actions rather than be observed or measured directly. Furthermore, Ertmer (1999) argued counting the number of available computers or the number of hours teachers and students use computers cannot determine the level of technology integration. It can be determined better by observing to what extent technology is used to facilitate teaching and learning.

Moreover, Blumenfeld et al. (2000) identified the problem with instructional reform efforts is trying to specify and study only one element, which could be new policy, curriculum, teacher-development, or standards and tests. In fact, in educational settings, various factors and dimensions interplay simultaneously to affect the results (Blumefeld et al., 2000; Eisner, 1985; Erickerson, 1986; Ertmer, 1999). For example, many teachers may feel limited equipment hinders their efforts to integrate technology; yet, why they feel they need more computers can be explained by their goals and beliefs. Some teachers may want more computers to cover the curriculum more efficiently while others may want more computers to extend student learning beyond the current content and formats (Ertmer, 1999). The interaction among various factors will be much more complex than this example presents. Therefore, qualitative research methods seem more appropriate for investigating teacher beliefs and what contextual factors interplay to affect the teachers' decision-making and implementation of technology integration. Then, more comprehensive and believable conclusions can be drawn for further investigations.

DATA COLLECTION

In qualitative studies, the investigator(s) should serve as the primary instrument to gather data because it is impossible for a nonhuman instrument to include and adjust to the variety of realities encountered during investigation. Only the human instrument has the ability to comprehend and evaluate the meaning of interaction between the investigator and respondents (or objects). Although all instruments are value-based and able to interact with local values, only the investigator(s) can recognize and deliberate those perspectives and biases (Lincoln & Guba, 1985). Hence, as a primary instrument of this study, I specify my viewpoints and biases brought to the field. The decisions about selecting the studied school and participants were deliberately made for obtaining fruitful information to answer the research questions. Methods of data collection including observations, interviews, and documents and artifacts analyses were utilized to collect data from different participants and data resources according to the situations during fieldwork.

Researcher as an instrument of data collection

Erickson (1986) identified two approaches to data collection in the field. One approach is to make the process intuitive and inductive, and that means researchers should start their observations without any anticipation or preconception and then discover the patterns or themes through lengthy and intensive observations. The other, opposite approach is to make the process as deliberative as possible so researchers keep making intentional decisions on sampling, hypothesis generation, and hypothesis testing. However, Erickson explained that people always bring their experience-frames of interpretation to the filed and, one can argue, there are no pure inductions. Therefore, researchers should become reflexively aware of the frames of interpretation brought to the setting.

I considered myself a holder of constructivist beliefs about teaching and learning, and having positive attitudes toward technology integration. Since research literature about technology integration mentioned in the previous chapter indicated that constructivist learning environments could support teaching/learning for understanding, and teachers who believed in constructivist teaching strategies would tend to use technology more and with diverse applications, I expected those teachers who held constructivist beliefs about teaching and learning and who integrated technology with their instruction more frequently and in varied ways would be more effective technology users. The educational technology standards for teachers and students promoted by ISTE (see Appendix A) were my lenses to focus upon their effectiveness in technology integration (ISTE, 1998, 2000). Knowing the potential for inadvertently guiding the participants' responses in certain directions because of my biases, I made efforts to design open-ended interview questions and to avoid disclosing my beliefs and values while interacting with my participants. I was cautious about my biases during the processes of my data collection and analyses, and different methods used to ensure the research quality will be presented later.

Purposive sampling

Purposive sampling can increase the range of data and to maximize the possibilities of uncovering multiple realities (Lincoln & Guba, 1985). Selecting information-rich cases purposefully allows researchers to study these cases in depth and learn more about issues which are central to the study purposes (Patton, 1990). Therefore, I conducted this study in a public high school located in Taipei City, because public schools in Taipei have more funding and resources and information is spread rapidly and conveniently in Taipei compared with other areas in Taiwan. A professor of my Master study helped me connect with the technology coordinator of the school I wanted to study. The technology coordinator, Mr. Wang (all names referred in this study are pseudonyms) who was in charge of the Network and Resource Center in that school helped me recruit the participants. Mr. Wang was also experienced in getting funding to conduct technology-related projects with his colleagues. Moreover, he organized most of the professional development programs about technology integration in that school. Therefore, he was much more familiar with the overall situation of technology integration in that school and was the appropriate gatekeeper I should contact for access permission (Glesne, 1998).

The school is a so-called whole school, combining junior and senior high school (from seventh-grade to twelfth-grade). In Taipei, there are 26 public high schools and 22 private high schools totaling 1,696 classes and 75,084 students (Department of Education, Taipei City Government, 2004). In general, students in Taiwan attend junior high schools close to their communities. However, while school location is an important factor in deciding which senior high school to attend, the ranking accorded to enrolling scores derived from the High School Joint Entrance Examination is the primary index for parents and students to consider whether a school is the right match. The senior high school section of the studied school ranks around the fifth place in all high schools in the Taipei area so the academic achievement of the high school students is above average. Table 3.1 shows the class numbers and student population of the school, and Table 3.2 shows the teachers’ education levels.

Table 3.1 Class & Student Population

Number	Junior High	Senior High
Class Number	19	48
Student Number	682	1815

Data retrieved from the school website, 2005

Table 3.2 Education Level of Teachers

Education Level	Number	Percentage
Doctoral Degree	2	1.2%
Master's Degree	65	37.6%
Bachelor's Degree +	47	27.2%
Bachelor's Degree	59	34.1%
Total	173	100

Data retrieved from the school website, 2005

The school has built a reputation for technology integration. For example, the school was rated "Excellent" in the annual national evaluation on Information Software and Teaching Material Resource Centers conducted by the Ministry of Education from 1999 to 2001. The Ministry of Education stopped conducting this evaluation in 2002 (Ministry of Education, 2002c). Mr. Wang told me that although the school culture encouraged teachers to combine technology with their work not all teachers used technology on a regular basis. Some of the teachers were frequent users, and others were intermediate or rare users. Hence, the school was an appropriate site for my study because I could compare different levels of technology integration and investigate what factors cause these differences.

Although I brought certain frames to the site, I was unsure from whom or where to reap fruitful data. Mr. Wang helped me recruit fourteen teachers of different grades and different subjects so I could acquire a more comprehensive perspective from them. After talking with all the teachers and observing several classes, I chose twelve teachers who were more comfortable with being observed and interviewed. Only one participant was in the middle school section, and data from this teacher was mainly used for the purpose of triangulation, which means using multiple data sources or data-collection methods to verify arguments or findings (Gleesne, 1998; Huberman & Miles, 1998, Janesick, 1998; Lincoln & Guba, 1985; Merriam, 2001). Table 3.3 lists the demographic information of these twelve teachers.

Table 3.3 Participants' Demographic Information

Case #	Gender	Age	Teaching Exp.(year)	Technology Use (year)	Grade Level	Subject	Education Level
1	F	36-45	15	2.5	12	Chinese	Master's
2	M	36-45	20	4	10	Physics	Bachelor's
3	F	46-55	28	2.5	12	English	Master's
4	M	46-55	25	< 1	12	Math	Bachelor's
5	F	26-35	11	4	10	Chinese	Master's
6	F	26-35	2	2	10, 11	Biology	Master's
7	M	26-35	7	3	10, 11	Art	Bachelor's
8	F	26-35	6	4	10, 11	Music	Master's
9	F	26-35	6	2	11	English	Master's
10	M	36-45	16	10	10	Earth Science	Master's
11	F	46-55	23	3	10	Geography	Bachelor's
12	F	26-35	5	2.5	7-9	Domestic Science	Master's

Technology Use: using technology for classroom activities

Methods of data collection

The data of this study was collected from three sources: observations, interviews, and documents and artifacts. Interview data was the main data source, and data collected from classroom observations and the documents were used for generating and focusing interview questions, and triangulating teachers' report. Appendix B lists the summary of data collected from the twelve participants.

Observations

The main advantage of observation is to provide rich present-experiences. For example, capturing nonverbal cues such as gestures and body languages can sometimes result in an entirely different interpretation (Lincoln & Guba, 1985). During observation, Researchers attend to multiple factors simultaneously and participate in the world of the participants. To grasp the full range of variation in the school setting, perspectives of different participants, and relationships of internal and external effects of the setting and its surrounding environments, it is necessary to start from general and comprehensive observations. As the research proceeds, the researcher gradually moves to a more restricted observation focus; then begins to investigate possible relationships between the setting and its surrounding environments (Erickson, 1986).

Mr. Wang arranged a seat in the Network and Resource Center for me during my stay in the school. Before obtaining consent forms from my participants, I had spent two months in that school getting familiar with the school organization, available resources, class schedules, locations, and so on. These data were useful for my description of the school background and for the triangulation purpose. After acquiring consent from the participants, I scheduled observation time with them. However, three teachers were teaching twelfth-grade were under the pressure of preparing students for the coming College Joint Entrance Examination, so they told me that their instruction was restricted to a repetitive process of lecturing, assessing, and reviewing. The three teachers were not able to use technology in their instruction of these twelfth-grade students. Therefore, I only observed nine participants' classes.

All teachers I observed would briefly introduce me to their students when I entered their classrooms for the first time. For each class observation, I would arrive at the classroom earlier to wait for the teacher. After a short conversation or simply a greeting with the teacher, I would enter the classroom and sit in the back of the classroom with my laptop computer. During the observations, I typed in my field notes, trying not to distract students. Most students seemed used to my presence and comfortable with someone watching them because the school was a popular placement-school for many student teachers to conduct their practice teaching. The purpose of collecting observation data was for developing interview questions, complementing interview data and confirming responses of the participants. Initially, I recorded a variety of data. Based on the preliminary analysis of my field notes, my observation gradually focused on what and how technology was used, teaching strategies, learning activities, interactions between the teacher and students, and interactions among the students. In addition, the interview questions were gradually taking shape and, when my observations neared the end I arranged for interviews with the teachers.

Interviews

Interviewing is one of the most common ways of understanding human beings, and it has various forms and uses (Fontana & Frey, 1998; Lincoln & Guba, 1985). I conducted a formal interview with each participant and had two informal interviews with a participant because of her eagerness to share experiences with me. All formal interviews were audiotaped and ranged from 50 minutes to one-and-half hours. The two informal interviews covered broad topics so each talk lasted more than two hours. The formal interviews were semistructured, and the two informal interviews were unstructured. Structured interviewing means an interviewer asks a respondent a series of predetermined questions within certain response categories. On the other hand, unstructured interviewing attempts to understand complex human behavior without imposing any preset questions and categories which may limit the open inquiry (Fontana & Frey, 1998). For the two informal interviews, I simply listened to the participant without recording her words. However, after the talks, I would immediately write down important statements and stories in my journals.

An interview can be used to collect the present data of persons, events, activities, feelings, motivations, or concerns. It can also be used to uncover what was experienced in the past or what is expected to be experienced in the futures (Lincoln & Guba, 1985). During the interviews I collected data from the past, present and future regarding the participants' motives for integrating technology, prior learning and teaching experiences, beliefs about teaching, learning, and technology, plans for future technology integration, and so on. Before each formal interview session, I asked the participant to fill out a form including questions about demographic information and the participant's agreement levels on eleven constructivist statements (for a translated version of the form see Appendix C). Collecting the demographic information helped me understand general background information of my participants, and asking them to identify their agreement levels on the constructivist statements brought up more concrete ideas for further investigation on their beliefs about teaching and learning in the following interview sessions (for the responses see Appendix D).

At the beginning of formal interview sessions, I would ask the teachers to explain their responses to the eleven constructivist statements so I could elicit more information about their pedagogical beliefs. The interviewees would express their viewpoints on those statements and the applicability of those constructivist concepts in their daily instructional situations. Then, I interviewed the teachers with a list of prepared general questions (for a translated version see Appendix E), and more specific questions for the teachers based on my observations and other collected documents. As the teachers disclosed their opinions, sometimes more questions were added to clarify or to deepen my understanding about their responses. Because I conducted all formal interviews in two weeks and sometimes I interviewed two participants a day, I did not have time to transcribe each interview tape immediately. After leaving the field, I would usually listen to a tape once or twice and type into my journals my reflections on how to improve interview questions and interactions with participants to prepare myself for the next interview.

Documents, records, and artifacts

The web pages and newsletters of the school provided rich information about the school background. Out of curiosity, I used Google to search for information about my participants and located various information including some teachers' learning background, professional achievement, syllabi and lesson plans. Many of these lesson plans were designed to combine technology with instruction but only six participants had put such lesson plans online. I also acquired samples of ten participants' syllabi. In the syllabi, teachers identified course objectives, sources of instruction content, teaching and assessment methods, etc. These online lesson plans and syllabi were valuable for comparing with data gathered from classroom observations and interviews. Other data collected from the Internet helped me understand the school and my participants better.

Besides the data collected online, four teachers E-mailed me samples of Power Point slides, video clips and animations used in their instruction, and two teachers gave me samples of lesson plans or handouts. I collected three artifacts of student group projects. Also, a teacher who had received funding from the Taipei City Government to visit British public schools gave me a report. In that report, she compared the technology usage for teaching English by her colleagues and the teachers of the schools she visited.

Although lesson plans or syllabi created by the teachers seemed pretty relevant to my research questions, not many detailed lesson plans or syllabi were available. As researchers (e.g., Calderhead, 1996; Borko, H., & Shavelson, 1990) indicated, most teaching-planning is mental and informal and most teachers would write formal instructional plans only to meet administrative requirements. In other words, the teachers would rarely create written lesson plans or syllabi for their classes unless they were required to do so.

DATA MANAGEMENT AND ANALYSIS

Actually, I had conducted initial data analysis before I started collecting data directly from the participants. Being aware of the amount of qualitative data, I employed strategies for data reduction and concentrated my investigation on aspects more relevant to my research questions before, during and after the data collection. Still, the collected data was massive, and I needed effective methods to analyze the data. In the following section, I described how I reduced the quantity of raw data and how I referred to the constant comparative method promoted by the grounded theorists (Glaser, & Strauss, 1967; Strauss& Corbin, 1998a, b) to code the data and gradually uncover the patterns hidden in the data.

Data analysis strategies

The collected data are not immediately ready for detailed analysis and require some processing. Huberman & Miles (1998) suggested data analysis includes three parts: data reduction, data display and conclusion drawing/verification. Moreover, they argued the three processes occur before, during, and after data collection. Due to the daunting data amount of qualitative research, data reduction is a necessary process. Choosing a conceptual framework, framing research questions, and deciding sampling strategies or research instruments all involve data deduction (Huberman & Miles, 1998). While I made these decisions, I chose what variables or objects to pay attention to during the data collection.

During my stay in the school, I employed concepts promoted by the grounded theorist such as the constant comparative method and theoretical sampling (Glaser, & Strauss, 1967; Strauss& Corbin, 1998a, 1998b) to reduce the data amount and to focus my future data collection. After a day of observations or interviews, I would process the raw data that evening. For example, I reread the field notes or listened to the audiotapes once or twice. Because I recorded field notes with my laptop computer, I did not write my comments or questions on the margins. Instead, I highlighted important segments with different font colors and typed in my reflection beneath the notes. After reading or listening to my data, I would compare the new data with the data collected before and write down my reflections.

In the reflection journals, I recorded various questions including sensitizing questions (e.g., What is going on here? How did the teacher divide students into groups? Why did the teacher's practice demonstrate very traditional styles as well as very constructivist styles?), theoretical questions (e.g. Dose the data show me teachers having more constructivist beliefs using technology less often than teachers with traditional beliefs? Was subject matter an important variable in deciding how technology was used?), and practical/structural questions (e.g. Where can I find articles talking about this topic? When and where to find the teachers to schedule interview sessions?) (Strauss& Corbin, 1998a). These questions helped me organize my thoughts and plans for conducting general data analyses and focusing my further investigation.

Although I kept working on data reduction during the data collection, I was intimidated by the data amount when I was about to code the data. As a novice researcher, I had very limited experiences in conducting small-scale qualitative research. Glesne (1998) characterized coding as “a progressive process of sorting and defining and defining and sorting those scraps of collective data (i.e. observation notes, interview transcripts, memos, documents, and notes form relevant literature) that are applicable to your research purpose” (p.135). I had never really comprehended the complexity of coding until I faced my raw data the first time. I assumed I should develop certain major code clumps to sort the data and then break a major code into numerous sub-codes to sort the major code clump (Erickson, 1986; Glesne, 1998). However, I did not really know where to begin.

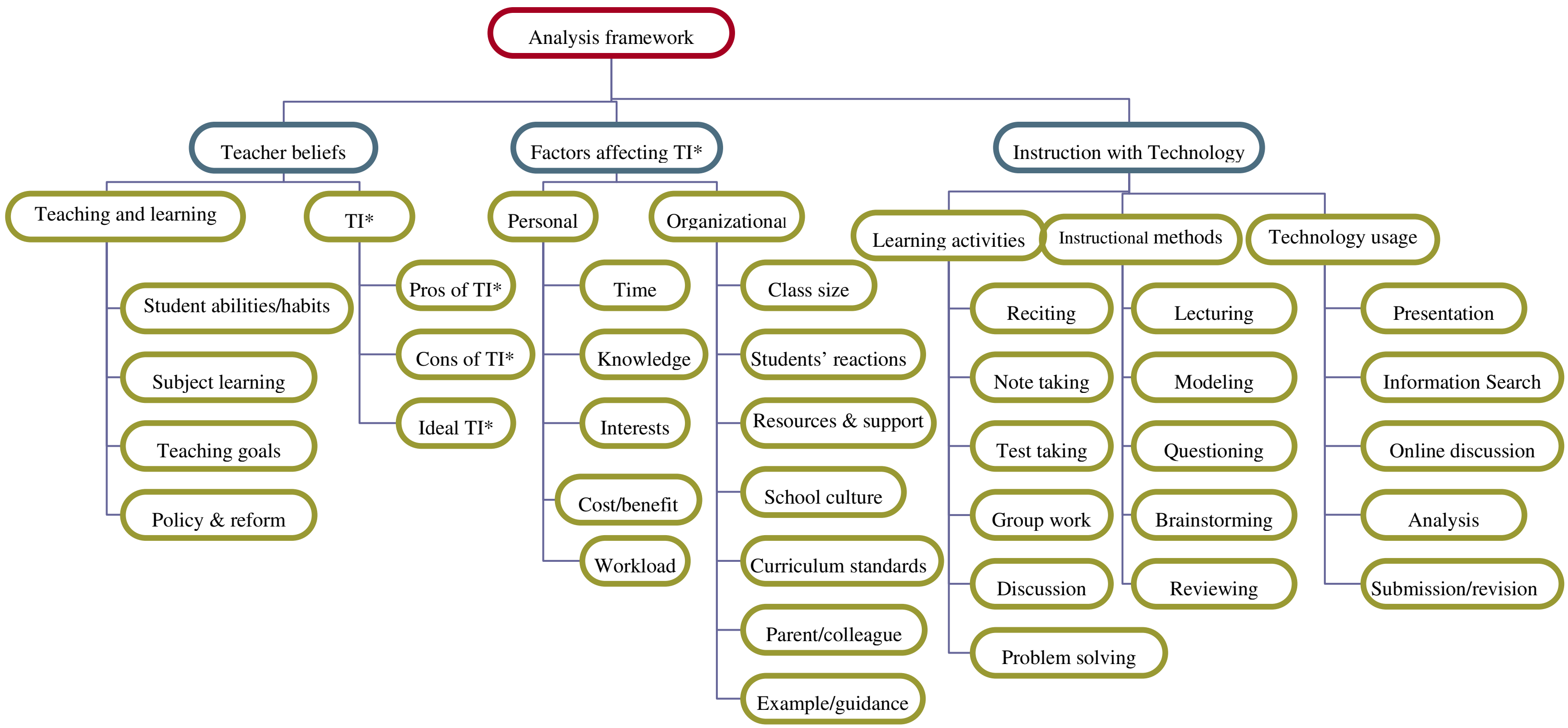
Fortunately, discussions with my professor and a book (Merriam, 2001) recommended by him provided me with more concrete concepts and steps for the coding process. Based on the constant comparative strategies, Merriam (2001) specified steps to analyze the messy qualitative data. Referring to these steps and concepts promoted by grounded theorists (Glaser, & Strauss, 1967; Strauss& Corbin, 1998a, b), I started the open coding which is the process of defining categories and their related properties. I did not use analysis software to help me analyze my data because I preferred interacting with my data personally. However, the keyword-search function of computer software was able to reduce the drudgery of locating certain data segments. Therefore, after working with printed-out materials or index cards, I would update the data stored in my laptop computer.

I printed out all the raw data first. Then, I chose a part of my field notes and read the notes, and my reflection was added to the notes again and again. While reading the notes line-by-line, I wrote the names of categories I created for segments of data on the notes and also on a separated memo. I would add, modify, or delete the names of categories on the list during this process. After I repeated the coding process several times and felt satisfied with the temporary coding of these notes, I would move to another part of field notes, transcripts or documents. I repeated the process and compared the list I generated for the earlier set of data and then added new category names to it. I repeated the process over and over until I finish coding all my data. Then, I opened all the files stored in my laptop computer and started typing in category names into the files according to my coding of the paper materials and the coding list. As I typed in the names, I would still add, modify, and delete categories and the search function helped me make this revision more easily. I repeated these processes and noticed certain patterns and regularities emerging. Sometimes I worked with printed materials or index cards but most of the time I worked with the digital files because I gradually found it easier to update the coding in all files using my laptop computer.

Appendix F is a working coding list for the observational and interview data after I had reviewed all the data and refined the coding list several times. Gradually, some categories were subsumed into broader categories (i.e. axial coding process). Some categories were discarded because they were less relevant to my research questions. Relevant categories were integrated and refined to support responses to research questions (i.e. selective coding) (Glaser, & Strauss, 1967; Strauss& Corbin, 1998a). The relationships of main categories represent concepts emerging from the data. Merriam (2001) suggested that generating a chart or table is a good way to examine the appropriateness of categories.

Figure 3.1 presents the final version of the data analysis framework. Actually, the data analysis framework turned out to be pretty consistent with the conceptual framework proposed in Chapter 2. The purpose of this study is to investigate how teachers' pedagogical beliefs and their beliefs about technology usage for supporting instruction affect their practices for technology integration. Also, according to the reviewed literature, teachers' technology usage may not fully reflect the teachers' beliefs because various contextual factors interplay to influence their decisions. Therefore, the data analysis framework consists three main categories which are teacher beliefs, other factors affecting technology integration, and instruction with technology. Because of the large amount of contextual factors affecting technology integration, in order to organize the contextual factors I divided all factors into two subcategories, personal and organizational factors. Then, I organized all categories related to teachers' practices into three groups: learning activities, instructional methods, and technology usage.

After continuous data comparison and refinement, I found the data showed on interrelationship among different categories. Figure 3.2 highlights the relationships of the main categories. For example, teachers' pedagogical beliefs would affect how the teachers viewed computer technology and what technology could put their beliefs into practices. Meanwhile, their ideas about how technology could do might change their perception about their own beliefs and practices. Teachers holding different beliefs might perceive different barriers or contextual factors which influence their technology integration. Based on their beliefs, concerns, and perceived obstacles, teachers decided how to integrate technology in their classrooms (i.e., the shadowed part of Figure 3.2). The findings and conclusions derived from the data will be discussed in detail in the following chapters.



* TI: Technology Integration

Figure 3.1 Analysis Framework

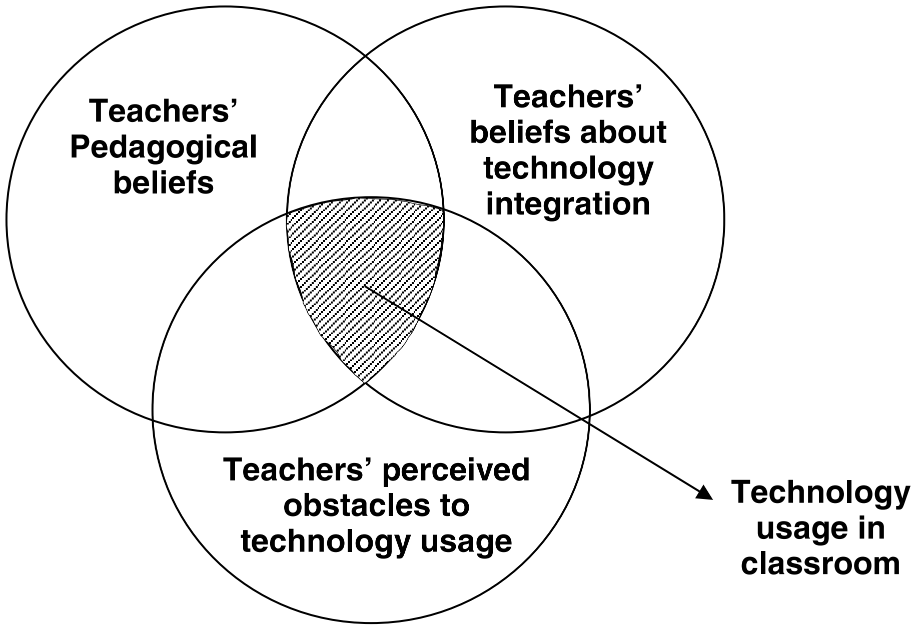


Figure 3.2 Relationships of Main Categories

RESEARCH QUALITY AND ETHICALITY

Quantitative researchers use various criteria such as validity and reliability to ensure their research quality. Similarly, qualitative researchers have to consider the issue of how to improve research quality. In this study, I employed various strategies including prolonged engagement, persistent observation, triangulation, peer review and briefing, and member checking to ensure the research quality during the processes of data collection and analysis. Furthermore, fulfilling my obligations as a researcher, I had to deal with certain ethical issues while interacting with people in the field. At the end of this chapter, the methodology limitation regarding how to generalize the research findings of qualitative case studies is identified, and how this issue could be tackled is also discussed.

Ensuring research quality

Guba & Lincoln (1998) suggested two sets of criteria for judging the quality of an inquiry. One set of criteria is trustworthiness, and the other set is authenticity. The criteria of trustworthiness include credibility (paralleling to internal validity), transferability (paralleling to external validity), dependability (paralleling reliability), and confirmability (paralleling to objectivity) (Lincoln & Guba, 1985). The criteria of authenticity include fairness, ontological authenticity (enlarging personal constructions), educative authenticity (leading to improved understanding of the constructions of others), catalytic authenticity (stimulating action), and tactical authenticity (empowering action) (Guba & Lincoln, 1989). The criteria of trustworthiness are aligned with traditional criteria for judging the quality of research work, and some criteria of authenticity overlap with the critical theory and focus on the power issue and on how to take actions to empower people. During the processes of data collection and analysis, I paid more attention to the criteria of trustworthiness but still bore criteria of authenticity in mind during my investigation. The authenticity concept was one of the lenses focusing on certain incidents, asking questions and making comparisons among the collected data. However, as aforementioned, I had to be aware of my prejudices and the trustworthiness criteria helped me in this aspect.

Lincoln & Guba (1985) described several techniques to ensure the criteria of trustworthiness such as: prolonged engagement (i.e. spending sufficient time at the research site), persistent observation (i.e. focusing on the elements and characteristics most relevant to the investigation), triangulation (i.e. using different data sources to add the trustworthiness of the data), peer review and briefing (i.e. receiving feedback about the research work from other researchers), rich and thick description (i.e. describing research contexts in detail), and member checking (i.e. sharing research materials with participants to confirm accurate presentations and interpretations). Miles & Huberman (1994) also provided similar techniques for avoiding obvious biases. The following description explains how I utilized these techniques to ensure the research quality during my processes of data collection and analysis.

Prolonged engagement and persistent observation

Before I officially obtained consent forms from the participants and started my investigation, I got permission from the school administrators to observe the school activities without participation. I talked with my prospective participants and searched information online to understand the school and the teachers better. As I obtained consent forms and started my study two months later, I was familiar with the school organization, classroom layouts, the equipment status, and so on. Therefore, I did not have to pay attention to these aspects, worrying about missing things relevant to my study during the observations and interviews. In addition, I kept reviewing the collected data and asking myself questions to focus my further data collection (Strauss& Corbin, 1998a, 1998b).

Triangulation

Different data collection methods and data sources allowed me to be more confident with the consistent data and my interpretations or to investigate the causes for inconsistent data. For example, classroom observations usually supported the participants' statements about their personal beliefs during the interview sessions and in the documents. However, in very few cases, inconsistent data caught my attention and collecting or comparing more data provided explanation for the inconsistency. Because my temporary office was the Network and Resource Center, the frequent talks with Mr. Wang and two other teachers of technical support served as another source of triangulation.

Peer review and briefing

During the data collection, I regularly discussed what I was investigating and discovering with my brother and sister who are public school teachers in Taipei. The discussions were not formal sessions of peer review, but my two siblings were more familiar with the situation of technology integration in Taipei and they provided me with viewpoints which might contrast mine. Their questions kept me alert to my biases. After returning to campus, I met with my professor regularly to report on how I analyzed and interpreted the collected data. The professor guided me through the data analysis process and cautioned me against making any judgment or argument based on my feelings rather than scientific evidence. I also requested two graduate students in the Education College who are Chinese speakers to review my coding strategies. Occasionally, I would share my experiences about how I conducted my study in Taiwan and how I coded and interpreted the collected data with some graduate students who are from Taiwan, and I would ask their opinions on how I could improve the data analysis and presentation.

Member checking

Before entering the field, I was aware of the possible difficulty in receiving the participants' feedback once I had finished my data collection and left Taiwan. Therefore, I deliberately asked the participants to confirm my interpretation during my stay at that school. For example, during observations, I would record my questions or uncertainties and asked the teachers to clarify or confirm my interpretations to the dynamics in classrooms. During interviewing, I would regularly summarize the responses to the interviewee to verify my interpretations of their comments. The interview transcripts frequently showed patterns of reporting, summarizing, and confirming or dissenting. Most of the time the participants agreed to my interpretations, and when they disagreed they always provided more explanation to clarify my misunderstanding.

Ethical issues

Following the ethical codes demanded by institutional review boards (IRBs) to conduct this study seemed simple at the first glance, since it was not a type of medical or intrusive research. I could easily remove the participants' identities from the written research documents by assigning numbers or pseudonyms to my participants, or lock all materials in a cabinet so others will not have access to them. However, I did face dilemmas regarding research ethicality. With the title of a PhD candidate from a prestigious university, I was regarded as an expert by the teachers. Therefore, several participants persisted in asking my opinions about how to improve their technology integration. Also, some participants expressed their interest in knowing other teachers' practice so they could learn from good examples. I understood I should not share my opinions on the effectiveness of their instruction and my learned knowledge of other participants. I should avoid affecting their practice or discussing my personal beliefs or knowledge (Glesne, 1988). Furthermore, protecting the confidentiality of my participants is a basic concept of doing research. Hence, I could only politely explain I could not judge the participants' practice and it was my responsibility not to share such knowledge as a researcher. However, it was not easy to reject their request because they showed sincerity of being willing to learn. Just as Glense's (1988) description, I felt myself an "exploiter" who acquired all data I need from them without making any contribution.

In addition, Mr. Wang told me the school administrators would like to know my findings because the findings would be valuable for refining school policies regarding technology integration. It could be considered a reasonable request for most administrators. Nevertheless, the technology coordinator could easily connect a response or statement in my writing with a specific person, distributing the detailed information might violate my participants' right of confidentiality and cause them some trouble or discomfort. Therefore, I shared my concerns with Mr. Wang. I decided instead of reporting on my findings in detail, I would write a summary in Chinese to identify teachers' perceived needs or difficulties and possible ways to improve technology integration in the school without including any participant's identity or responses.

Methodology limitation

Although various techniques were used to ensure the research quality of this study, how my interpretation of the collected data will be perceived, reinterpreted and generalized by the reader is beyond my control. Stake (1995, 1978) and Patton (1990) explained case study research focuses on particularity and complexity rather than on generalization of the studied case. While findings themes and verifying hypotheses are important, the primary responsibility of the researcher is to understand the case thoroughly (Stake, 1978). However, as Stake (1998) addressed, case study researchers cannot avoid the issue of generalization. Through descriptive narrative to present the contexts and multiple viewpoints, I expect my readers can vicariously experience what I was exploring and recording, recognize the similarities to their own experiences, reach their own conclusions, and naturally apply the findings to their future experiences (Stake, 1978, 1995, 1998).

SUMMARY

This chapter presents the analytical framework, data collection methods, data analysis strategies and ways to ensure research quality and ethicality of this study. To conduct a study consisting of compatible ontology, epistemology and methodology, I chose the interpretivist paradigm and qualitative case study methods as the analytical framework because this framework allows me to infer and interpret the beliefs of the participants and to explore the influence of other contextual factors on the teachers' technology usage. In qualitative research, researchers are regarded as a primary instrument of data collection so I illustrated my perspectives and biases first. By using myself as a research instrument, I collected data from three sources: observations, interviews and documents and artifacts. Through constantly making comparisons and generating concept-related questions, I coded all raw data into categories and kept modifying the categories. Gradually, I decided the relationships of the categories and demonstrate the relationships with charts. To ensure the research quality, I paid more attention to the criteria of trustworthiness but also kept the criteria of authenticity in mind. Techniques such as prolonged engagement, persistent observation, triangulation, peer review and member checking were used to ensure quality. Still, how a reader will interpret and generalize the findings of this study remains a question. Finally, I also illustrated how I dealt with the ethical issues about affecting the participants' practice and protecting their confidentiality.

Chapter 4: Findings

This chapter illustrates the findings of this study. To provide a clear description about the contexts in which participants defined their work and implemented their ideas of technology integration, this chapter starts by describing the educational settings faced by the teachers including the influential college admission system and school organization. Then, the current situations of technology equipment, technical and administrative support and extent of implementation of technology usage in the studied school are presented to indicate the influences pressing upon the participants. Four representative cases are chosen to highlight the key characteristics related to the research questions. Therefore, how the teachers' beliefs affected their perceived issues and barriers to their ideal instruction and technology integration and how the beliefs and factors are interrelated are further revealed by discussion in the following chapter.

EDUCATIONAL SETTINGS

Stake (1978) stressed the importance of thorough description of the research context to help readers recognize the particularities and similarities so they can decide how to generalize the research findings of case studies to their experiences. Therefore, the following sections describe the educational environment surrounding the participants from the broader educational community to the classroom settings. The general description serves as an overview of the situations the teachers encounter every day when engaged in their teaching tasks.

Joint examination and school organization

The study field is a public high school located in Taipei City, Taiwan. Generally, in Taiwan, junior high schools comprise the seventh- to ninth-grade students, and high schools include the tenth- to twelfth-grade students. The studied school is a so-called whole school consisting of students from seventh-grade to twelfth-grade. However, the numbers of classes and students in the senior high section are about triple the size of the ones in the junior high section. According to Mr. Wang, the technology coordinator, and teachers I have talked with, more attention and resources are given to the senior high section. The academic achievement of the students in the senior high section is comparatively high because their enrolling scores ranked around the fifth place in the High School Joint Entrance Examination among 26 public high schools and 22 private high schools in Taipei area.

Before moving to the tenth-grade, students must choose what division to attend. Their choice decides the test subjects in the College Joint Entrance Examination. For example, students who choose the science division will take tests on subjects such as physics, chemistry, and biology, and students wanting the liberal arts division have to take tests on history and geography. In addition, there are three common test subjects: Chinese, English, and mathematics. Due to the educational reform, a college student recruiting system combining recommendation and examination was introduced as an alternative. A general test is taken first, and then another test is held by the department a student wishes to enroll in. This way, students who have extra talent in certain areas but are not successful in other academic subjects can have another chance at getting admission (Pan & Yu, 1999). However, the College Joint Entrance Examination is still taken by most high school graduates to decide whether they are qualified for admission to their preferred colleges.

The competition of the College and High School Joint Entrance Examinations persists in being a huge unsolved educational problem in Taiwan. Educational reforms over the years have all tried to tackle this problem. However, it is very difficult to eliminate the importance of the competition for the joint examinations in Taiwan (Pan & Yu, 1999; Yang, 2004). Teachers who teach subjects designated as tested subjects are usually under the pressure of covering enough content to prepare students for the joint examinations. High school teachers in Taiwan have to follow curriculum standards announced by the Ministry of Education because these standards are related to the test items in the joint examinations. Therefore, most of the teachers who teach the tested subjects feel obligated to cover more content related to the curriculum standards. Trying to teach as much as they can, most of the teachers in the studied school were unwilling or hesitant to allow students to spend class time exploring the content more fully on their own. Also, the average class size is about 40 students so the teachers could hardly pay attention to the learning of individual students.

Unlike teachers in the United States who stay in their own classrooms, most Taiwanese high school teachers do not have their own classrooms. But they do share offices with their colleagues. In the studied school, most teachers were assigned seats in the offices of their departments. This arrangement allowed the teachers to communicate with colleagues teaching the same subject more easily. The students usually stay in home classrooms but they went to special classrooms or labs for classes taught by the teachers who are in charge of those classrooms or labs. Most teachers went to the home classrooms to teach according to schedule and stayed in their offices during free periods. The teachers make reservations in advance when they need to use a special classroom or lab. In Taiwan, each class is assigned a home classroom teacher who usually teaches the class a subject and is paid especially for taking care of the class.

The teachers teaching the tested subjects of the joint examination face additional constraints on their curricula and assessments. Although the educational reform eliminated the constraint of using mandatory textbooks, teachers of the same subject and the same grade level had to choose textbooks from available textbooks published by companies following the curriculum standards of the Ministry of Education. Collectively, they adopted the same textbooks and decided schedules for covering content and evaluating students. Teachers normally took turns composing examination questions for the three big examinations in each semester: two midterms and one final. After each examination, student scores were calculated, and each teacher would receive the ranking result, listing the average scores of all classes at the same grade level. The three examinations accounted for 70% of the final grade so student performance was mainly evaluated based on these pencil-and-paper, norm-referenced tests. Students as well as teachers felt the pressure of competing with others. Berliner (2001) cited Lin's (1999) conclusion that given the mandatory curriculum, common texts, teacher guides, and the joint examination, teachers in Taiwan have very limited independence in their teaching and seldom make decisions concerning curricula and instruction of any importance.

Meanwhile, the teachers teaching those subjects which will not be tested in the join examination were given more freedom in making decisions about what and how to teach and evaluate their students. However, they do have to consider parents' concerns and students' workload, and they tended not to require students to devote much time and energy to assignments and evaluations. Students could consider the untested subjects unimportant and might not be motivated to make great efforts, and those students interested in these subjects might be discouraged from spending much time on homework by their parents. Therefore, no matter what subjects they taught, all participants agreed the joint examination greatly influenced their instruction.

Technology equipment and technical support

The school had been gradually building up a reputation for emphasizing students' abilities in foreign languages and computer skills. It was funded by the Ministry of

Education and the Taipei City Government to conduct various projects or establish equipment for encouraging technology integration. For example, a project called E-Book started from 2002 studying how teachers and students would teach and learn with high-end technology. Each participant student was equipped with a tablet PC, and they could connect to the Internet everywhere in school via the wireless network. The school was the first high school in Taiwan to install the wireless network. In 2002, the school also received a ten-million NT$ (about $300,000) funding to equip each classroom from the ninth-grade to eleventh-grade with a computer, an LCD projector, and Internet connection, and every teacher could apply for a desktop computer or a laptop computer. Although the school seemed to be the forerunner of technology integration in Taiwan, the school has not obtained additional large grants to replace equipment since then.

Ten out of the twelve participants reported they were short of certain equipment or technical support but most participants agreed they had easier access to technology equipment and resources than their counterparts in many other schools. Mr. Wang and two teachers of technical support in the Network and Resource Center were responsible for technology business such as managing computer labs, constructing and maintaining the campus network, and planning professional development programs. In addition, one technician in the library would help solve technical problems such as installing software and scanning for viruses for the teachers. The former principal and Mr. Wang were given credit for the equipment acquisition and the promotion of technology integration in the school. Intensive professional development opportunities were provided, and teachers were encouraged to use educational technology for communication, instruction planning, classroom instruction, record keeping, and grading.

Although the skill training for fostering teachers' ability of operating a computer is crucial for technology integration (Bitner & Bitner, 2002), many researchers emphasized the design of professional development programs should consider the social or pedagogical contexts rather than simply transmitting knowledge and skills about computer operation (e.g., David, 1996; Ertmer, 1999, 2005; King, 2002; Schwab& Foa, 2001; Windschitl & Sahl, 2002; Zhao et al., 2002). Yet, most training programs offered in the school focused on skills of operating a computer, and the program content was irrelevant to ideas about how to integrate educational technology with instruction in creative ways, let alone changing instruction fundamentally.

Perceived general technology usage

After the data collection and analyses, a general picture of the technology integration in the school emerged. Technology was still being used to support the familiar teacher-centered instruction (Cuban et al., 2001). Many teachers of the school viewed technology integration as equivalent to the most commonly recognized mode of technology integration in Taiwan: using presentation software such as PowerPoint to present content (Chen, 2003; Cheng & Chen, 2004; Lee, 2001). Similar to Ku, Pan, Tsai, Tao, & Cornell's (2004) description about instruction in the East, the instruction of most teachers in the school remained the teacher-centered, lecture-based approach, and little interaction occurred in the classrooms. With educational technology, the teachers could provide more materials and information, and they could highlight important concepts in various ways to grasp students' attention. But every participant reported the pressure to follow the planned schedule and cover more content, and some teachers regard PowerPoint slides as powerful means for transmitting knowledge to students. Interestingly, unlike Becker's (2000) findings that indicated teachers who want to cover broad content tend to view technology-usage unfavorable for content coverage, some teachers in the school seemed to be inspired by how technology could save them time in content coverage--especially when they had to catch up with the schedule. Teachers might go through as many slides as they could; while they felt relieved covering the planned content according to the schedule, the students could not possibly have deep understanding of the content (Brophy, 1982, Koschmann et al., 1996).

Some teachers could not integrate technology in ways they wanted because of their limited computer knowledge and skills. The statements of most participants expressed doubts about their computer knowledge and skills. Mr. Wang described his experiences of working with his colleagues on some e-learning projects. He found some of the teachers had good ideas but had too limited technology skills to implement their ideas. Although teachers wanted to have more interaction with students, the functions provided by PowerPoint with which they were most familiar could only allow them to execute their instructional design in inflexible or even clumsy ways. Moreover, some teachers were not motivated to combine technology usage with current instructional theories because they did not experience successful technology integration themselves. Not only were students not exposed to creative and explorative learning activities with technology usage but also teachers themselves might never be able to experience designing and conducting instructional activities with technology (Ertmer, 2005). Therefore, many teachers had no intention to implement new ways of technology integration. Most commonly observed classroom interaction was one-way knowledge transmission. Like most Asian students, they seldom expressed their opinions in class (Ku et al., 2004). Even though some teachers would ask students questions, most questions did not encourage critiques, debate or further exploration because the teachers seemed to have certain right answers in mind, and when students did not make the correct responses the teachers would directly explain the right answers. In the long run, students seemed to be unwilling to freely express their opinions.

In addition, teachers' efforts toward designing and conducting instruction in original ways with technology might not be understood and appreciated by parents, students, colleagues, or administrators. Many of these people do not use technology on a regular basis, and they believed compared with traditional instructional approaches, creative technology integration could not improve student performance in the standardized tests. The study of Rice, Wilson, & Bagley (2001) addressed this same issue: teachers who integrated technology with constructivist instruction might feel penalized by the people holding traditional beliefs surrounding them. For instance, there was an English teacher who decided to integrate technology in ways different from traditional instruction. She would list big questions on slides and encouraged students to spend much time discussing the questions and interacting with her and their peers. However, her teaching worried some parents, because they did not believe free interaction would lead to high scores and the students were uneasy with such unconventional teaching. She listened to the concerns from the administrators, and this incident was talked about among her colleagues. This instructional design was discouraged by parents' and students' complaint and by reaction from her peers and her supervisors. Therefore, most teachers would like to change the means to convey the content but their concepts and approaches to teaching have not changed much because of these pressures.

FOUR REPRESENTATIVE CASES

Four cases among the twelve participants were chosen to present how the teachers' pedagogical beliefs and beliefs about the potential of technology integration affect their decision-making in technology integration and what other factors interplay to influence their beliefs and practices. Because the four teachers possess critical characteristics shared by other participants, the four teachers serve as the representative cases of this study. Hence, the description of these four cases may shed light on important elements toward answering the research questions.

Miss Huang: fostering higher-order thinking

In the semester of my study, Miss Huang taught two twelfth-grade Chinese classes. She got her Master's Degree half a year ago. Already highly regarded by her colleagues as an excellent teacher before she started her graduate study, Miss Huang would, for example, spend much time creating handouts and supplementary materials to strengthen students' abilities in test-taking. She paid close attention to students' test scores and the ranking of her classes at the same grade level. She once asked the students to write a topic in a school composition examination, and the College Joint Entrance Examination in that year had the exact topic for the composition test. Her colleagues were surprised and thought she was really good at teaching. She felt the commonly-accepted definition of being good at teaching was to help students score high in the joint examination. However, after her graduate study, she had doubts about her role as a teacher. Still, she needed to prepare her students for the joint examination because it was a primary focus of the school. Yet, she questioned whether the sole purpose of teaching was examination preparation. As she employed strategies to prepare students for the examinations, she also wanted her students to form the habit of self-regulated learning and she decided to spend less time "studying for the students." Because she focused on fostering students' critical thinking, she felt uncomfortable with forcing students to memorize knowledge and testing students repetitively to improve their test scores. She reflected, "It seems I don't know how to teach anymore."

Teacher beliefs and technology integration

On a webpage, Miss Huang specified her ideals of instruction were to: (1) integrate science and technology with humanities, (2) emphasize local culture as well as worldview, (3) value individual and group honor, (4) foster student' humanist dispositions, existential thinking, and positive perspectives about life, (5) encourage students to think independently, manage stress appropriately, and develop the ability of self-regulated learning, (6) facilitate students to establish proper and efficient learning habits so they can enjoy learning, and (7) appreciate individual characteristics and differences to help students explore their potential and specialties. Similar concepts were consistently addressed in her talks. Her description of learning Chinese was aligned with the concepts of cognitive constructivism. She said, "Teaching Chinese mainly focuses on students' abilities of listening, speaking, reading, and writing." "In addition to these abilities", she continued, "students also need to integrate their prior experiences with currently learned knowledge and then to construct their own learning." She wanted to improve not only students' ability to learn Chinese but also to possess the disposition of being an effective learner. She said,

> I surely hope what I do is not restricted to solely transmitting knowledge but to really help students in other aspects. Well, I hope concurrently I can attend to my educational beliefs which are guiding the students to think independently and to form more thorough learning attitudes.

Miss Huang's beliefs and instruction are also consistent with the ideas of social constructivism. For example, she thought teachers should encourage students to learn from each other. From the experiences of working with others, students could strengthen their ability to communicate their own ideas and improve their performance by being inspired by peers' ideas. She made efforts to create a collaborative learning environment so the students could learn how to respect the viewpoints of others and think critically on their own. Not viewing the teacher as an authoritarian role, she said,

> I consider we live in a multi-value society. Each perspective should be given a chance to be represented, advocated, and communicated, and then people may reach a consensus. If a student believes something is right, I think we should not devalue his/her viewpoint just because we are senior. Therefore, most of time I would provide guidance rather than giving lectures.

Miss Huang would design learning tasks for students to engage in a project with technology for a long time. She once showed me some students' work on a project conducted the semester before. In order not to take class time, she asked her students to undertake the project during a winter break. Given a broad topic, "river," the students could choose working with peers or working alone to create a multimedia storybook. Miss Huang sent the students a Word file listing the guidelines about how to undertake the project. In the beginning of the following semester, Miss Huang held an exhibition and contest, and the students used PowerPoint or Flash to present their final products. Finally, according to the evaluation of Miss Huang and the votes of all students, Miss Huang awarded the winners prizes. In this project, educational technology was used for presenting the learning task, supporting the creation of student work, and sharing the final products.

To Miss Huang, educational technology also provides means for constructing an environment of open discussion. She talked about an assignment requiring the students to discuss a controversial topic using an online discussion board. She described,

> We conducted an online discussion project about betel nut girls[1] earlier. Some students argued our society does not provide better job opportunities for the youngsters who are dropouts or are from single parent families. Therefore, the betel nut girls have no other choices but taking this kind of job commonly

[1] In Taiwan, some young girls sell betel nuts in booths on roadsides. To attract more customers they dress very little and sometimes flirt with their customers. Most of the girls do not have good education, and this occupation is usually despised by the public.

> regarded as disgraceful. After this project we realized teachers need to understand students' perspectives more. It is not like, "Well, being a betel nut girl is not good, period." Actually, students have their own opinions.

A purpose of designing the online project was to "connect to students' daily life" because "they had the experiences of seeing people do this kind of job, and they had their own perspectives on it." She figured, "Some students might have sympathy with these girls while others felt contempt for them, and their perspectives can be closely related to their family education." She viewed herself as a guide to encourage the students to express their perspectives, debate with each other, and finally reach mature consensuses. Miss Huang would also reflect on the learning processes and try to improve her instructional design. Regarding the online discussion project, she did not feel the discussion resulted in insightful conclusions, and she became aware of the importance of providing students with guidelines or rubrics for evaluating their performance.

Even though Miss Huang attempted to design instruction based on the background and individual differences of the students, she admitted the task seemed too challenging to accomplish. If she had to consider individual students' specialties and learning preferences, it would be impossible to design an activity. She said,

> Most of the time, I seize each right moment to teach my students based on the context. However, I am constrained by several factors such as time, class size, and my understanding of the students' background. See, these are conflicts between ideals and realities. I am willing to understand their background but how can I get the information? If students are not special in some ways, for example, having some behavior problems, I cannot really know their background. It is also very difficult to find out the information such as their prior learning attitudes, habits and achievements from pencil-and-paper tests.

Recently, she foresaw "an interesting possibility of technology integration" which was to compile students' learning processes with educational technology so the teachers could better understand the learning experiences of the students. She did not recall that any colleague had thought about this application, and she planned to implement this idea so the students and other teachers could benefit from the accumulated records.

While acknowledging the advantages of technology integration, Miss Huang believed something cannot be replaced by technology. She summarized,

> To me, the most important advantages of using technology are to accumulate records and information and to provide a platform for open discussion. The online discussion function compensates for insufficient class time, and students can freely post their comments. We can read all students' comments and raise their viewpoints for discussion. However, I think individual care, for example, the interaction between the teacher and the students is important. Interaction among people can have positive effect which cannot be replaced by technology.

To use or not to use technology

While being asked the reasons why she decided to integrate technology with her instruction, Miss Huang mentioned the school environment first. She shared a perspective with research findings (e.g., David, 1996; Ferneding, 2003; Hung & Koh, 2004; King, 2002; Staples & Pugach, 2005) that how administrators could facilitate a school culture of adopting technology for instruction was crucial. She described the former principal who had a strong will to promote technology usage in the school and the Ministry of Education provided the necessary funding for equipment acquisition. Also, "a positive competitive environment" was gradually formed because "Some teachers were using technology and, gradually, there was a comparison-effect, pushing more teachers into technology integration." Moreover, she felt technology integration is an unavoidable trend. Not only the school but also some educational organizations had been promoting technology usage, and opportunities for professional development were provided. She figured,

> If you are interested in certain topics, you will tend to attend the programs. The more programs you attend, the more you tend to use technology in your instruction.

Surrounded by the current school environment, she felt the need to strengthen her knowledge and skills of educational technology. Furthermore, her study in the graduate school affected her technology integration and instruction. She described herself that she used to focus on "something more detailed" before. After the graduate study, she became "more open-minded and eager to show the students a broader variety of perspectives." However, to conduct her instructional design with technology required various conditions coming together. For example, she recalled the situation of conducting the online discussion project,

> Our school allowed teachers much freedom at that time. I asked some teachers to get involved in the instructional design. Furthermore, some practicing teachers having a computer science degree helped us create the web pages. All conditions fitted together perfectly. Otherwise, given our busy schedule and heavy workload, especially for home classroom teachers, it would have been difficult to undertake this project.

Yet, compared with her colleagues, Miss Huang might not integrate technology with instruction very often. She talked about her decision on technology usage,

> If I can teach a lesson well with traditional ways, do I need technology? The reason I used technology was to complement the inadequacy of traditional instruction…. My decision of using technology is whether technology can accomplish effects which cannot be accomplished without it. If traditional teaching methods can accomplish the things I want to do, I would rather use traditional ways. Given our workload, I feel technology integration does take teachers more time and energy unless the teachers have accumulated their materials.

Sharing some same viewpoints with Hokanson & Hooper (2004), Miss Huang did not believe technology should be an indispensable element of successful instruction, neither did she believe technology could reduce her workload because "Once some workload is lifted, you may need to solve another problem." When I asked what her ideal technology integration would be, she replied cautiously,

> I cannot say I can clearly define what ideal technology integration is. To me, a lesson with a thorough plan in advance, a smooth process during the instruction,

> and an appropriate evaluation afterward is ideal instruction. I cannot make the judgment based on whether technology is integrated or not.

To her, "technology is simply a tool," and it is created "for serving people, not for replacing people." Whereas recognizing technology could be more advantageous in some ways than manpower, she thought "how we are going to use technology is more important." Not being over-optimistic about technology integration, Miss Huang was still open to the possibilities of technology integration, and she held a positive attitude toward the policy of encouraging teachers to integrate technology. She said, "Educational technology is new, and I am trying to figure out whether there are areas out of the reach of traditional instruction and these areas can be explored by technology." She also expressed,

> I think encouraging teachers to integrate technology is a policy of foresight because the relevant training and experiences are helpful. Many students learn how to search for information online or how to conceptualize and organize a paper with technology. All these learning experiences could be related to their teachers' technology integration.

Reflection on technology integration

Although she made efforts to integrate technology with her instruction in ways aligned with her pedagogical beliefs, Miss Huang did not feel her technology integration had necessarily led to effective learning. Sometimes, unsatisfying learning occurred because "most students' learning is often fixed and it is difficult to suddenly change their learning habits through several learning activities." Therefore, she considered her technology integration "a compromised improvement given the situations of real life" because the students were used to traditional teaching and declined to change their learning habits. Also, she was unsure whether her technology usage could encourage self-evaluation of the students although she recognized the importance of this ability. She believed, "if a learning activity is not a routinized instructional approach, it is unlikely that students can learn how to evaluate their own learning progress and outcomes." Instead of cultivating the ability to self evaluate, Miss Huang and the students usually depended on the traditional evaluation method, pencil-and-paper testing, to understand the learning outcome.

Equipment was also an issue because there were no computers and LCD projectors in the twelfth-grade classrooms. When Miss Huang taught the twelfth-grade, she would use technology less often due to the inconvenience of checking out the equipment or reserving a computer lab in advance. The school administrators and teachers decided not to install the equipment in the classrooms to prevent the students from being distracted. Because the twelfth-grade students faced the approaching joint examination, and the instruction was essentially guided by the examination; the twelfth-grade teachers usually focused on preparing students for the joint examination and asked the students to practice benchmark tests repetitively.

Miss Huang further stated the focus of technology integration was not about whether technology was used but was more about how to implement ideas appropriate to every grade level and how to facilitate teachers to change their beliefs and instruction. Her statements were consistent with the proposed concept of technology integration (e.g., Bitner & Bitner, 2002; Brickerner, 1995; Hokanson & Hooper, 2004; King, 2002; Sandholtz et al., 1991, 1997; Windschitl & Sahl, 2002). She indicated these issues were needing further observation and, from the educational perspectives, the implemented technology integration needed "a core change" in instruction rather than using technology to replace old means of teaching (Bruer, 1993; Papert, 1993; Tunison, 2002). After being asked to elaborate the meaning of a core change, she continued,

> I think we need more research on instructional approaches. If the teaching approaches do not differ much from traditional teaching, what we do is simply to replace some practices with technology. This is not the change. It is just a change

> of tools. However, I think we depend on researchers to reveal the core values of technology integration.

So far, she did not feel well-informed about how to integrate technology with more effective teaching approaches, neither from the policies nor from professional development programs. The teachers were not provided with good examples of technology integration, and they were not shown organizations work on innovative studies or applications. She felt, “Everybody has talked about technology integration for many years but there has been limited influence” and “Most applications we saw were traditional approaches with new tools.” Most of the time, she searched for new ideas and tried to execute the ideas with or without support from others. Nevertheless, she considered her experiences of technology integration a necessary process rather than a difficult test of endurance. She smiled and said, “During the process of incorporating a new concept, people might not support my ideas but I would ignore the obstacles because of my passion.” She continued,

> I would support my own ideas and try to overcome the difficulty. Actually, there was no real difficulty. Maybe we can say it was more about understanding. If people understood my ideas, they might come up with some even better ideas. Therefore, I didn’t feel I had any difficulty in implementing my ideas. I would try to put my ideas into practice. If you don’t try, how can you know where the problems are?

Still, she admitted that sometimes the discrepancy between her ideas and reality occurred when her ideas were too idealistic. “I might not have much time for conducting a project but asking for good quality of work takes time,” she said. “Furthermore”, she added, “I might consider a topic appropriate, but students did not share the same vision and prefer to spend their time elsewhere.” Therefore, she gradually developed strategies to cope with the situations. For example, knowing some students might not cooperate in working on the projects, she tried to stimulate those students by creating an atmosphere of positive competition among students. As for the multimedia storybook project, she knew some students would delay or even fail to turn in their products so she held an exhibition to motivate those students by showing them good work of others. She explained,

> This strategy was actually not about technology integration but more about my teaching experiences. You need to plan thoroughly ahead and then think about some mechanisms to motivate students. This is what I consider for as part of my instructional design.

In general, Miss Huang held positive attitudes toward the educational reform and technology integration but she was cautious about "some distortion occurring during the implementation." She expressed, "We applied some theories in the practices but we might misinterpret the theories or have no real understanding of their core values." She felt more open discussions were necessary and teacher beliefs played a critical role in undertaking a change. She concluded,

> I think it depends on how you view yourself as a teacher. If you regard yourself as a teacher capable of independent thinking, you will definitely have the aspiration to make a change. If a teacher is not this kind of person, having enough funding or equipment is useless….I think teachers of independent thinking are more willing to face the contextual constraints and to think about how to improve the instruction.

Mr. Lee: supporting interaction

Mr. Lee taught physics to eight tenth-grade classes when I was conducting my study in the school. To him, the tenth-grade instruction mainly focused on general knowledge, and the students did not really know what knowledge or specialties they want to pursue yet. In a web page, he described his instructional objectives for tenth-grade physics were to deepen students' understandings about physics based on their prior learning in junior high schools and to help students combine physics knowledge with everyday phenomena so they were motivated and inspired to use the knowledge for science, invention and applications. Regarding instruction approaches, he tried on find the balance point and to teach in ways acceptable to most students. He explained,

> Some students prefer listening to lectures and taking notes. Meanwhile, some students enjoy hands-on activities, while others don't feel they learn things from these activities and they would like to receive more organized content. Therefore, we employ more balanced approaches which can be accepted by the majority, and then we blend our ideals with these generally acceptable approaches. For example, one aspect of my ideal instruction is to encourage interaction in the classroom.

The interaction between Mr. Lee and the students and the collaborations among students were frequently emphasized. He did not rely entirely on a lecture-based instruction style which focused on transmitting knowledge from the teacher to the students. Mr. Lee said,

> My instructional goal is simple: to let my students learn from good examples. Instead of merely covering content, I hope my students can really learn things from my class. If covering content is the sole goal, technology can record all content and play back again and again. I can sit at the back and relax. Nevertheless, I think that kind of instruction is abnormal and I insist teachers should interact with students. I don't feel students will learn by simply watching video. My job is teaching which means my students can interact with me and learn stuff.

By dividing students into groups, Mr. Lee expected the students could learn from peers, and he stressed,

> I want my students to blend into a group. They need to identify with this group and explore ways to improve the whole group and themselves.

Therefore, interaction was a critical element in Mr. Lee's class.

Instruction and technology usage

Unlike most teachers in the school, Mr. Lee was in charge of a science classroom and taught classes in that classroom. Usually, around 40 students were seated in eight groups. A desktop computer was placed in the front, and a LCD projector was fixed to the ceiling. The computer and projector were essential teaching aids to Mr. Lee because he used the equipment to show PowerPoint slides in every class. Mr. Lee's instruction was similar to the instructional approach of cognitive apprenticeship proposed by Collins, Brown, & Newman (1989). Usually Mr. Lee's class started with an explanation of a concept using a text summary or a graphic in a PowerPoint slide. Animations might also be used to present concepts which were difficult to describe or comprehend through static media. Video clips could be used to demonstrate how to conduct an experiment and call students' attention to important details. Students would highlight the text or take notes during the explanation. Then, Mr. Wu modeled how to solve a problem with explained concepts. He spoke aloud his analysis of the problem and his problem-solving strategies, and he highlighted the concepts behind the problem-solving procedures. Later, another problem with similar concepts would be assigned for students to solve. Students in the same group would work together to solve the problem. After solving the problem, each group selected a spokesperson to explain their discussion or write the problem-solving procedures on the blackboard. Mr. Lee then reviewed the procedures written on the blackboard and gave higher grades to the groups solving the problems correctly. During the processes, he would query students to verify their answers or to clarify their misconceptions with more questions or demonstrations.

Mr. Lee mainly used PowerPoint slides to present the content and problems, but he often used the blackboard to demonstrate problem-solving processes because he viewed chalk and the blackboard a more flexible means to model problem-solving and to explain procedural concepts. Also, asking students to write down their problem-solving procedures on the blackboard allowed him to find their understandings and possible misconceptions. Moreover, students could learn from peers' mistakes or share ideas with the whole class. When the representative of each group was writing the procedures on the blackboard, other group members would watch the copied procedures closely and make suggestions for revising the procedures if they found something wrong in their preceding discussion. To correct students' misconceptions, Mr. Lee might revise the problem to reduce the difficulty level and explain the concepts in detail. After students seemed to grasp the concepts, he might then present a more difficult problem for them to solve. Therefore, chalk and the blackboard were still important teaching aids in the class because of their flexibility.

Because a large proportion of the students' final grade was related to group performance, students would cooperate with their group members to win higher scores. They were excited when their discussion finally got the right answer. When Mr. Lee asked a question, the students were expected to provide an answer as well as the reasons to justify the answer. To involve students in the classroom discussion, classroom participation weighed heavily in their final grade. The rationality of his thinking process was emphasized in this class. Sometimes Mr. Lee raised a complicated question and moderated a whole class discussion. Students would be involved in a brainstorming activity, and the students were encouraged to provide their thoughts to make the answer more thorough. Generally speaking, Mr. Lee's class was full of excitement and energy although the primary incentive he used to promote classroom interaction was extrinsic.

After a test, Mr. Lee would demonstrate how to solve some difficult problems but he would not solve all of the problems for the students. He tried to make each test a learning opportunity. For example, to revise a multiple-choice question, the students not only had to write down a correct answer but they also had to explain their thoughts and why other choices were wrong. Mr. Lee would give them extra credit for the efforts paid to the revision and deduct scores when the students failed to correct their errors. Therefore, if students scored high at first but did not pay attention to the revision, their final scores for the test might be lower than their peers who made more mistakes in the original test. Hence, the students could learn from their mistakes and improve their performance. Moreover, Mr. Lee encouraged students to search for help from peers rather than from him directly. If several students had discussed a problem together but could not solve it correctly, they could simply put their names on the paper and he would not lower their scores.

Although Mr. Lee did not identify his instruction as social constructivist instruction, his instruction definitely encouraged the students to interact with and learn from peers. Mr. Lee said he gradually developed his instructional approach through continuous experiments and revisions, and he was satisfied with his instructional approaches which had been employed for two years. For instance, he explained a change of his instruction and the following student change,

> Two or three years ago, I didn't allocate much time to allow my students to demonstrate their problem-solving. Going forward to demonstrate their ideas is very different from directly answering my questions. Students' concentration levels were very different. I found asking students to demonstrate how to solve problems could motivate the whole group. Before, when I asked a question, only two or three students in a group would try to answer my question. Others would read English textbook or practice mathematics problems. Now, fewer and fewer students would do off-task activities in my class.

In sum, there was much interaction in Mr. Lee's class and he conducted his instruction in ways consistent with the concept of cognitive apprenticeship. On a webpage, Mr. Lee described that his own instructional approaches focused on (1) showing students examples of everyday life, to demonstrate how to combine textbook content with everyday life; (2) requiring students to experiment on the learned concepts, and (3) strengthening students' ability for collecting useful information and evaluating students' learning through problem-solving and presentations. Technology was mainly used to present the concepts, examples or how to conduct experiments, and Mr. Lee himself still played the primary role of controlling the flow of learning activities and evaluating student performance. He declared, “I could only handle about two-thirds of the students three years ago but right now attending to 95 or 96 percent of the students’ learning is under my control.” Regarding assessment, he usually kept the class average around 60 out of 100 because he thought “For physics, a class average around 80 is kind of deviated.” He arranged tests and asked students to correct their errors, and then “The student performance in exams would naturally show normal distribution.”

Pedagogical beliefs and beliefs about technology integration

Emphasizing interaction, Mr. Lee noted student reaction to his instruction. He claimed,

> To me, ideal instruction is the way students can absorb instruction between the teacher and the students. If what I do can be accepted by my students, that is the best instruction. I don’t really care about others’ opinions.

However, he did not feel teachers should fulfill the preference or needs of each individual student. On the contrary, he thought, “It is not good to reject a teacher’s teaching just because you are not used to it.” He gave an example, “Some students might not feel comfortable enough to interact or discuss with peers but they could consider this approach as an opportunity to try something new.” While encouraging the students to learn how to accommodate to various instructional approaches, he argued teachers had to make adjustment in their teaching as well. He said,

> I think we teachers have to change ourselves gradually. If you view yourself as something like ROM [i.e., Read Only Memory], you will never change. However, if you learn as your students are learning, you will gradually adjust your teaching into ways appropriate for most students.

Hence, the reason he adopted technology in his instruction was to react to the changing environment and student expectation. Mr. Lee declared he could “go to a class and teach physics with a cane and a textbook” which meant he could use the cane to highlight important concepts on the black board mirroring the ones in the textbook. Mr.

Lee succinctly replied to the question why he started integrating technology, "Well, using technology is the trend, nothing else." Just as Olson & Eaton (1987) and Hodas (1993) indicated the adoption of innovative technology could allow teachers to demonstrate their willingness and ability of keeping up to date, Mr. Lee thought teachers who did not use educational technology "would be eliminated from the competition" and "would be viewed as a product of the last century by students." He expressed,

> I think it meaningless to look back on the glory past or to attach to the old methods because we are facing a product of this century which is identified by students. They won't share our opinions of valuing things and ways of the past. It is impossible to ignore educational technology and keep doing things in old ways. All you can do is improving your own practices. You design new instructional approaches to accommodate yourself to the product.

Because of his conception of technology, Mr. Lee and a colleague, who was also a participant of my study, were the pioneers of regularly using technology in the school. Three years ago they both taught tenth-grade physics and earth science and, at that time they decided to incorporate technology into the instructional design of the two curricula. According to Mr. Lee,

> Some teachers just symbolically used some slides for a special lesson. For example, to specifically demonstrate a lesson for administrators and colleagues, a math teacher might create some slides the day before the demonstration. Or, a physics teacher would use some video to demonstrate an experiment. Their technology usage was for embellishment rather than a routine.

After organizing all materials, Mr. Lee created PowerPoint slides for the two curricula, and his partner revised the slides for the curriculum of earth science. To make all lesson units consistent, Mr. Lee decided to create all slides at one time. He spent a whole summer vacation working continuously for about seventy days to finish the package of slides. He figured, "Working hard once could put me at ease later." After that, he only modified some data, recreated some animations, and changed certain parts of the slides according to student responses.

In addition to the slide content, Mr. Lee made necessary changes in his instruction based on the reaction of the students and parents. For instance, when he started using technology, about ten parents of students in the class complained their children could not keep up with the speed, or they were not used, to the approaches. He admitted he did not manage the new class situations very well so he understood the complaint and modified his instruction accordingly. For instance, he started to highlight important concepts in the textbook so students would know where to pay attention, even though his initial intention was to encourage the students to find meaning themselves. He explained, “I revised something while implementing my new ideas, and now I can say almost no parent will call our school to complain about my teaching.”

While being asked about the advantages of using technology in his class, Mr. Lee laughed and replied,

> First, using educational technology can reduce the time of using chalk and the blackboard, therefore better for my health. Second, Flash animations can express concepts more precisely than direct operations. Therefore, students can easily comprehend the concepts. Drawing some graphics on the blackboard can be precise but it is static. If I use some teaching aids to demonstrate the operations, only about five or six students can get it instantly. Most students just watch without connecting the phenomena with the concepts.

He further illustrated why animations were more obvious and easier to inspire students, “If I use an animation to demonstrate experiment processes, more than half of the class can understand the concepts because I can stop at every crucial point to explain the related concepts.” Whenever he stopped or replayed the animation, the students could pay attention to and understand the concepts more easily. Moreover, after Mr. Lee used technology, there was more interaction between him and the students because he spent less time drawing graphics on the blackboard with his back to the students.

Mr. Lee thought before and after his technology usage student performance in tests remained similar. He believed it was because more time had been devoted to asking the students to practice solving problems and to take more tests before his technology usage. However, he felt the learning processes and student motivation had improved much because of the technology integration. Finally, although Mr. Lee emphasized his ideal of instruction was to motivate students to involve themselves in the instruction and interaction, technology integration was not the decisive element to achieve the ideal instruction. He summarized,

> Using computers does not necessarily lead to interaction. You can observe that many teachers use computers in their classes but maybe six or seven students have already fallen asleep and about a dozen of students look absent-minded. Such technology integration is meaningless. Educational technology is simply a tool, or we can say it is like fuel for engaging students. If teachers are willing to motivate students and students start to embrace the ideal, students will enjoy the instruction whether educational technology exists or not.

Factors affecting instruction and technology integration

During the interview session, Mr. Lee described how factors such as parents' reaction, students' learning habits, the availability of necessary equipment, and pressure of content coverage interplayed to affect his instruction and technology integration. At first, the reaction of some parents and students seemed to trouble him. For example, in a class there were usually five or six students who were not willing to cooperate with him. These students tended not to discuss with peers, do off-task activities or slept. They did not want to make the revisions after a test or do homework because they had not formed the habit. Mr. Lee sighed, "The positive learning atmosphere of the class was hence ruined by their behavior and attitudes." Moreover, their parents did not pay attention to their learning. Some of those students might pass the important examinations such as midterms and finals but still got a fail at the end of the semester because they did not turn in the assignments. Then their parents would come to question his evaluation. Mr. Lee stressed, “In fact, I had explained the assessment in the beginning but some students did not listen to me.”

Second, the out of date equipment made Mr. Lee feel frustrated and he explained his hesitance at assigning students homework using technology was partly due to the equipment issue. During our talk Mr. Lee pointed the broken screen on the wall, “See, this screen has been broken for two years but they don’t want to fix it.” He continued,

> My computer is very dated and sometime the screen freezes without a reason. You haven’t seen my computer broken but I actually wanted to kick it all the time. We haven’t updated our equipment for years. Can you believe we are still using CRT monitors?

Because his teaching materials were all stored in the computer, without the computer Mr. Lee would have trouble teaching. Also, he felt the students would not be used to the instruction without technology. He described his unpleasant experience of trying to fix the computer last year,

> My computer was broken several times and very unstable last year, and sometimes I needed to fix the computer right away. You know a period is about 45 minutes, and I spent 20 or 30 minutes solving computer problems. If this situation happened only once, the students would not say anything. However, I had to fix the computer and the projector twice in three or four periods in a same class. Right away, parents of that class called the principal to report on my time waste. Well, because of the calls, we got a new projector.

When he had trouble with the equipment, he thought about teaching in home classrooms but he found the computer system in home classrooms was even more dated. He expressed his concern about the stability of hardware,

> If I am equipped with new and good system, I don’t have to worry about the hardware and I can focus on my teaching. I usually worry that my computer or projector will have a breakdown and I won’t know where the problem is. I believe fixing a computer problem often takes more than fifteen minutes.

In addition, Mr. Lee indicated the very availability of equipment affected his technology integration. “Unlike some classes joining the E-Book project, my classes do not have the equipment to conduct all kinds of learning activities using technology." Some students did not have computers at home so he did not want to assign homework requiring the students to use computers or the Internet. After being asked whether he would consider bringing the students to a computer lab, he replied,

> Most computer labs were reserved for computer subjects. Since we already had the computer and LCD projector in the classroom, we simply make good use of the available equipment. Also, if I want my students to search for information online I won't ask them to do it in class because we don't have much time.

Therefore, not having enough time was another critical issue for his technology integration. He agreed he always had the pressure of covering content. He believed he needed to cover more content because most students did not know what to learn. He figured, "If I skip some content, they'll think I've neglected my duty." He added, "Although the students have learned some concepts in junior high, they never think failing to understand the concepts is their own responsibility unless I re-teach these concepts." Mr. Lee was not comfortable with skipping some content and spending more time conducting activities with technology because he felt "If the students fail to answer the relevant questions while taking exams, their parents will call administrators to complain." He believed most parents would not agree with the idea of technology integration and they tended to think students had to use educational technology only for computer subjects. Mr. Lee assumed most parents would think physics teachers should focus on physics curricula. Only if he covered the mandatory content would the parents admit their children had to be responsible for their own learning. He explained,

> We at least need to cover 70 percent of the content learned in junior high school quickly, and then we can spend more time teaching the new content. Otherwise, students nowadays tend to eschew the responsibility and blame their teachers for failing them in exams….You need to beware of the feelings of parents as well as students. Some students would visit me after they moved to upper grade levels, and they did not complain to me about their physics learning because they knew I had covered most important content.

Overall, Mr. Lee felt satisfied with his current technology integration and student reaction. Regarding new ideas and future applications, he did not plan to change his practices yet but he said he was open to change. His decision to make a change would depend on student reaction. He found, “Students before were different from students nowadays, and maybe two or three years in the future, the students would prefer other ways of instruction.” “For instance,” he speculated, “they may prefer watching or operating real things directly to watching video or animations vicariously.” To Mr. Lee, observing students change and then changing his instruction accordingly was interesting and fulfilling. He said,

> Some teachers suffer from melancholia because they think they repeat the same teaching materials year after year. You know, if you observe the differences among students at different time, you will feel teaching is pretty interesting. You may plan to design some activities or instruction to improve the students. I always feel satisfied with the improvement of my students because the students will show their gratitude. Teachers have to change according to student changes.

Ms. Chen: emphasizing content coverage

I met Ms. Chen in the Network and Resource Center when she was attending a meeting held by Mr. Wang. Mr. Wang invited several teachers of different subject areas to join a project funded by the city government to establish a web-based radio station aiming at the high school students in Taipei as its audience. Ms. Chen was a member of the project. Mr. Wang introduced me to Ms. Chen, and she told me she was trying to establish a partnership which would allow her students to practice English through telecommunicating with the students of a high school in England. After we talked about my study, she described her visit to England a year ago. After winning a grant from the Taipei City Government, she went to England for a whole semester to understand the situation of integrating technology with language teaching in British high schools. During her stay in England, she visited two high schools and an organization called BECTA

(British Educational Communications and Technology Agency). After returning from England, she finished a research report and submitted it to the city government. She cordially gave me a copy of the report. In our first meeting, Ms. Chen gave me the impression of an advanced technology user.

Before formally interviewing Ms. Chen, I asked her to mark her agreement levels on eleven constructivist statements. She enthusiastically supported those concepts of constructivism and marked the highest agreement level on each statement. Then, she said she used educational technology in various ways including searching for information online, keeping students records, creating teaching materials, designing instruction, presenting curricular content, asking students to submit papers via E-mail, and even publishing her own web pages. Her responses supported my first impression that she was an advanced and frequent technology user. Also, I predicted that she could integrate technology with constructivist teaching approaches since she showed enthusiasm about the ideas of constructivism. However, the following interview session turned out to be a surprise.

Purposes as an English teacher

Obviously, the joint examination played an important role in Ms. Chen's work as a high school English teacher. She directly announced her instruction goal was to help her students score high in the joint examination. To achieve this goal, she thought the students needed to "learn a lot of stuff in a short period of time" because "learning a language needs to memorize a lot of stuff." As a twelfth-grade English teacher, Ms. Chen definitely felt the pressure of preparing the students for the approaching joint examination. In each semester, students in the high school section had to study six to ten types of English materials including textbooks and magazines. "Not only students but also teachers--everybody is exhausted," she said. In the joint examination, the questions for the English test are from a wide range of areas. Moreover, the national average score of the English test is usually ranging from 30 to 40 out of 100, and this means the English test is pretty difficult for most high school students. Due to the difficulty level of the joint examination, Ms. Chen felt if she taught easier content, the student performance would be worse.

She explained, “To reach the high standard set up by the College Entrance Examination Committee, we have to try our best even though we know many students are aiming at a goal which they may fail to accomplish.” “However,” she continued, “we assume the students have to strive for the goal.” Ms. Chen felt she had to teach content of high difficulty levels and cover as many materials as she could because “the questions on the exam could be related to all kinds of areas and different areas have different keywords.” Hence, the resulting instruction and assessments were difficult and the amount of content was intimidating. Ms. Chen admitted she could not consider the learning of the students of low abilities. She said,

> When I was teaching, I would find some poor students falling asleep because they couldn’t get it. I didn’t know how to help them because English learning is accumulative. The level of our instruction and assessment usually follows the level of the joint exam. About one-third of the students have reached this level, and my instruction is mainly for these students. I cannot attend to approximately one-third of the students whose abilities are very low.

Normally, the class size was about 40 students with various abilities. Like most teachers in the school, Ms. Chen said she tried to find “a balance point” so her instruction could meet the needs of most students. “Actually, it is difficult to find that point,” she concluded. Consequently, she considered dividing students into classes according to their ability levels a good idea. The currently implemented method of dividing students into groups such as liberal art division and science division based on student interest cannot reduce the ability diversity of English learning in every class. Ms. Chen felt helpless about this situation although she had sympathy with those students who could not follow the instruction. She said,

> Some learning tasks are important but they are simply beyond the students' abilities. In such a short time, they cannot take care of everything. We need to feel sympathy for them because they are pitiful under the pressure.

Indeed, the students were under much pressure because they had to study five or six subjects for the joint examination. To ensure the students would follow the schedule studying the required materials, Ms. Chen usually tested the students immediately after she finished a lesson unit. To her, evaluation was important, because she could know how the students learned from her teaching and repeatedly evaluating students forced the students to study. She explained,

> Students have many subjects to study. In the joint exam, they do not compete with others solely in English. They need to prepare for many subjects. If I don't test my students they will pay less attention to learning English. They may feel English is important but teachers of other subjects may push them to study their subjects by giving more tests. It seems teachers giving fewer tests cannot improve student performance. I have no choice but have the students take tests all the time.

In sum, Ms. Chen identified her purpose as a teacher is "to meet student needs," and she considered scoring high in the joint examination was the most pressing need of her students. Her instruction and evaluation were based on this purpose. She agreed "helping students enter good universities was the most important thing" because "students would feel bad if they couldn't achieve their goal." To accomplish the goal, Ms Chen thought helping students learn in the most efficient way to be her top priority.

Experiences and beliefs about technology integration

Ms. Chen regarded technology integration as an unavoidable trend. "If you are not doing it now, you eventually have to do it later," she commented. To learn necessary knowledge and skills for using educational technology, Ms. Chen seized every chance to attend professional development programs provided by the school and organizations outside the school. Also, she would ask her colleagues for help. However, she recalled, "At first, we resisted the idea of technology integration promoted by the former principal because we did not know anything about the network and related things." Similar to Miss Huang, Ms. Chen thought the promotion by the former principal was critical for forming the culture of technology usage in the school. Becoming aware of the trend, more and more teachers started using technology. Ms. Chen said,

> Had the former principal not promoted the idea, we would not have attempted to integrate technology with our instruction. Promoting technology integration led to involving more teachers in various projects, and joining the projects shaped the milieu of using technology. Gradually, more teachers felt the pressure and started or expanded their use of technology.

Ms. Chen laughed and continued, "Everybody was integrating technology, and if you don't do it, you would feel the pressure." Furthermore, she revealed her insight into the reason why most teachers started conducting technology integration,

> I found many teachers started using technology because they also needed to cover a lot of content. Although we have to spend much time creating PowerPoint slides after school, we can teach a lot of content with the slides in a short period of time. I think teachers of all subjects have the common concern of content coverage.

Therefore, most teachers including those who refuse to use it at first started using computers in their instruction. Ms. Chen suggested, "They might decide to use technology because others were using it, but they would find later that it was pretty timesaving." "For example," Ms. Chen added, "the created stuff such as slides could be used again and again."

It seemed to Ms. Chen saving time and covering more content were important advantages of using technology because these two issues were mentioned several times during the interview. For example, when I asked her whether she thought all high school curricula required teachers to cover much content, she replied instantly,

> Definitely! If a teacher cannot follow the schedule to finish certain content, well, go do PowerPoint slides to go through the content. It is absolutely faster.

By intuition, I doubtfully asked, “Oh, surely it is faster but can the students understand or digest so much content?” Ms. Chen confidently explained,

> Well, it depends on the teacher. For example, once I used PowerPoint slides to teach phrases, and you know what? I could present fifty phrases in a period. I have done the calculation. Using PowerPoint slides, I could teach five times the content of using the blackboard only. After I went through those phrases, I gave the students a test. Because I could replay the slides again and again without writing and erasing the blackboard, the time saving was worth the effort of spending much time creating the slides in advance.

Her reasoning was, “I could present content quickly with technology” and “because I covered more content, my students could learn more.”

In Ms. Chen’s class, besides using PowerPoint slides to present curricular content, she occasionally asked students to write papers with computers and then E-mail her the papers. She would mark corrections on the electronic documents and sent the documents back to the students. Also, she thought about compiling the revised papers and E-mailing all students the files. Hence, all students could read work of their peers and corrections made by Ms. Chen. She felt using a computer for writing was a trend and the students needed this training. Yet, she only brought the tenth- or eleventh-grade students to computer labs because there was not enough time for covering the content of the twelfth-grade. Ms. Chen felt, “Since the students will not answer questions on computers in the joint examination, asking them to key in papers is wasting their time because typing the articles requires an extra process.” Therefore, the twelfth-grade students wrote papers by hand, and she marked her corrections on the papers directly. “Although electronic documents allow me to keep records, I have to consider their needs,” she explained.

Not having enough time was always an issue to Ms. Chen no matter what grade level she taught. For instance, she described,

> When I taught the eleventh-grade, I taught the science division and had only four periods a week to cover the content. I had so little time that I felt bringing them to computer labs for typing was wasting time.

In general, Ms. Chen held a positive attitude toward technology integration. She believed technology and language learning were "the perfect match," because "language learning focuses on voices and images" and "technology can easily highlight concepts such as the prefix and the suffix of words." However, it seemed whether her technology usage was efficient weighed the most in her decision-making process. She said, "If the students could learn more or be more motivated, we would be willing to use technology." "However", she continued, "if we felt it wasted time, we would stop using it."

Reasons for not using technology

Ms. Chen decided to integrate technology with her instruction because she believed, "Surely the best thing about using technology is saving time." Interestingly, her primary reason for not using technology was it could waste time. Ms. Chen confirmed, "If I have more free time, I would digitalize all my teaching materials because I think using slides is the quickest and most effective way to teach." However, the main focus of the twelfth-grade teaching was to prepare the students for the coming examinations so the teachers would have many benchmark tests for the students. The routinized practice seemed to be even more efficient and hence eliminated the need to use PowerPoint slides. She illustrated the class routine,

> We use many handouts in teaching the twelfth-grade. What I mean by handout is actually a published test paper. It lists important concepts and detailed explanation. All we need to do is explaining the part which students don't understand. If we don't give the students handouts after presenting PowerPoint slides, they will forget everything. Currently, I just give them handouts without using PowerPoint slides.

Ms. Chen described such instruction was "student-centered" and, instantly, I repeated "student-centered" dubiously. She replied affirmatively,

> Yes, I gave them a test paper first. The student took time answering the questions. Then, we corrected the errors, and the students raised questions for the parts they did not understand. We repeated this pattern everyday.

Obviously, she believed such “student-centered” instruction was appropriate for teaching the twelfth-grade students in terms of efficiency. She stressed,

> I found everyone was trying to find a shortcut. Why do the students agree to cooperate with us? They work really hard. Why are they willing to go through this painstaking process? It is because they all agree leaning in this way is efficient.

Originally, Ms. Chen created PowerPoint slides to teach the twelfth-grade before but she found she could not reuse the slides because the English teachers decided to change textbooks and supplementary materials frequently. She said,

> This semester I have seven kinds of new textbooks or materials to teach. It is already difficult and time-consuming to become familiar with the content of the seven kinds of materials, not to mention creating slides. What I created before cannot be used this year because we won’t test on the old content. Therefore, I would not use the materials which I had spent hours and hours creating. I found using published handouts was more efficient.

Ms. Chen felt even if she wanted to use the slides created before, students would not pay attention to the teaching because the students would think the content was not directly related to midterms or finals. Moreover, she did not have time to teach extra content. “Really,” she reflected, “the English teachers should negotiate the amount of content and allow ourselves more flexibility in deciding what content to teach.” Therefore, Ms. Chen thought the benefit of covering the content more quickly was not worth the cost of her time investment. Currently, teaching with handouts directly was more convenient.

In addition, inconvenience of equipment access was another issue to Ms. Chen. The twelfth-grade classrooms were not equipped with computers and projectors because the classroom teachers worried some students could not resist the temptation to play games. They thought it easier to control the situation by canceling the plan of installing the equipment. This decision troubled some teachers of the twelfth-grade who wanted to integrate technology in instruction. Ms. Chen expressed her concerns about reserving a computer lab for using the computers and projector,

> I have to be acquainted with the environment because the computer lab is not for my exclusive use. Teachers using the lab earlier may change some settings or unplug some devices, and some computers may be broken. Hence, I need to spend at least half an hour earlier to check the lab before I bring the students in.

Also, she worried some students would play games and she could not attend to every student's behavior. Unconfident with her computer knowledge and skills, she felt bringing students to a computer lab too stressful. Again, the time pressure was related to her anxiety while using a computer lab. She portrayed "a teacher in a computer lab was like an octopus handling many things all the time." She continued,

> I would also wish computers would not freeze because I couldn't present the content fast enough....When I was facing a problem with technology, I needed technical support in time. Without support, I could only idle there, wasting class time. Therefore, before using a computer lab, I would ask a technical person to help me fix all problems. I felt uneasy to leave this person to solve all problems alone so I had to accompany him for about half an hour.

On account of those experiences, it is no wonder the description of her ideal technology was related to equipment. She described,

> There is a wonderful product called the electronic blackboard. It can present the content beautifully and is easy to erase or save the content. I wish I could have an electronic blackboard put in a classroom dedicated to me. Because I can control all the conditions, I don't have to worry about technical problems. Therefore, I can feel secure about my teaching, using technology.

Discrepancy between beliefs and practice

According to the theory of goal orientation (Dweck, 1986), a learner with performance goals tends to focus on issues of ability whereas a learner with learning goals would emphasize efforts. Learners with learning goals view efforts as means to overcome obstacles and improve their abilities. Meanwhile, learners with performance goals want to look competent. Ms. Chen seemed to tend toward performance goals and the entity theory which regards intelligence as fixed, because she frequently mentioned the importance of abilities and expressed her sympathy with the students who are "unable to develop the important abilities." For example, when I asked her what else she wanted her students to learn besides English, she answered,

> Of course I hope my students can handle things well in various aspects, for examples, having good relationships with others or performing well in learning other subjects. Well, I think this depends on their abilities. In fact, everything is about abilities. I think different people have different abilities. A more capable student can take care of more things, maybe learning all subjects well and having better relationships. On the other hand, less capable people can only tend to fewer things.

Her instruction and evaluation which focused on preparing students for competing with others in the joint examination were also consistent with the orientation of performance goals. Furthermore, when I asked her whether she considered fostering students' ability of self-regulated learning, she thought the chances were slim. She believed students needed much help from the teachers, given so many subjects to study. "Almost every teacher wants their students to learn much content in a short period of time so it becomes impossible for students to be self-regulated learners," she explained. Therefore, the teachers had to specify schedules and assignments for the students to follow.

The above comments of Ms. Chen were consistent with her practices. However, near the end of the interview, Ms. Chen surprised me with her reflection on her visit to England. According to her, the educational reform conducted in England emphasized three main subjects: English, mathematics, and information technology. They believed strengthening students' abilities on the three subjects could foster students' self-regulated learning. For example, when learners were familiar with using information technology, they could search for information online and learn knowledge by themselves. Ms. Chen said, “I feel, if you have enough abilities on the three main subjects and are willing to learn, you can learn anything on your own.” She continued,

> We can encourage the self-regulated learning by providing a mechanism to evaluate the learning progress, and therefore students are willing to learn and find answers themselves. They learn on their own, take a test to certify their abilities, and move on to the next stage. They do not need to compete with others. This is my ideal education.

Finally, she indicated how educational technology could improve learning,

> A big drawback of schooling is students cannot learn at a pace appropriate to them. Therefore, they feel learning is boring and painful when they cannot keep up with most students. If you force those students who do not have necessary prerequisites to learn the same content as others, you are wasting their time. Integrating educational technology with learning, students can follow their own pace to learn through well-designed materials, and enjoy their learning.

Ms. Chen’s example supports the argument that teachers’ beliefs are not necessarily consistent with their practices (e.g., Borko et al., 2000; Fang, 1996; Richardson et al., 1991; Warfield et al., 2005) and a person may hold conflicting beliefs in the belief system (e.g., Green 1971, cited by Mewborn, 2002; Rokeach, 1968).

Mr. Wu: infrequent and cautious user

Before conducting my study, I tried to recruit participants in various subjects. However, at that time I could not find a mathematics teacher using technology for teaching. Some research findings (e.g., Becker, 2000; Huang & Waxman, 1996; Manoucherhri, 1999) indicated a very small percentage of the surveyed math teachers would use educational technology for teaching and learning mathematics. Similarly, most math teachers in the school did not initiate technology integration. Then I met Mr. Wu in the Network and Resource Center. At first, Mr. Wu did not seem to be a frequent technology user to me. Just as in the findings of the national survey conducted in the United States (Smerdon et al., 2000), most teachers I met at the school told me more experienced teachers usually used technology less often for personal and instructional purposes. Nevertheless, I found Mr. Wu and another teacher were the only two mathematics teachers who had used technology in teaching among the 19 high school mathematics teachers in the school. Mr. Wu started using technology for teaching mathematics when he joined the E-Book project. He was teaching the tenth-grade then and was usually willing to try new things, so he volunteered to participate in the project with his classes.

Before getting involved in the project, he had been experimenting on how to integrate educational technology to motivate and improve student learning. But he did not feel he had made much progress. Mr. Wu found it easier to spread an idea or practice in the school when the idea became a trendy culture or aligned with the current values (e.g., Blumenfeld et al., 2000; Fullan, 2001; Hoban, 2002; Zhao et al., 2002). Therefore, he could more easily undertake his ideas about technology integration after technology integration became a popular concept and the school environment provided necessary means and support. He was asked to do the demonstration of integrating technology with mathematics teaching when some groups from mainland China and England came to visit the school. However, he reported he only used educational technology for teaching certain lesson units of the tenth-grade mathemathics. To him, educational technology could motivate some students but it could not benefit most students given the current instructional conditions.

Instructional goals and former technology integration

Similar to Ms. Chen, Mr. Wu directly stated the primary goal of high school education was to prepare students for the joint examination. Therefore, Mr. Wu felt he could not adjust his instruction to meet individual students' learning experiences and needs because of the difficulty level of the joint examination. To help students solve mathematics problems quickly so they could score high in the exam, he sometimes had to resort to traditional instructional methods such as more lectures, drills and practices. He said,

> I found the difficulty level of the joint exam currently was getting back to the level years ago. Yes, the exam is getting difficult again. Only studying the textbooks is not enough to score more than 30s out of 100. Without extra practice, training by teachers, and benchmark tests, the students cannot score high in the exam. According to my experience, for students to achieve higher standards of math scores, old methods work the best. If you allow them to learn on their own, their scores will be way below the standards.

To Mr. Wu, high school mathematics required the students to possess certain prerequisite mathematics knowledge so they could interact with the teacher. He explained the learning attitudes of some students were passive and they had given up learning mathematics a long time ago. Hence, the students had very limited abilities and learning experiences to handle the content of high school mathematics. Mr. Wu was concerned if he designed his instruction based on those students' learning experiences, his instruction would stay at the lowest level. Since it was impossible to design instruction to accommodate to the high, medium, and low achievement levels, the instruction of Mr. Wu focused on the majority whose abilities were at the medium level. Mr. Wu shared similar perspectives with Carraher & Schliemann (2000) that classroom mathematics education should not reduce to everyday mathematics and students should be able to generalize what they learned in classroom to their real life experiences if the teachers had provided adequate learning activities linking mathematics concepts to everyday situations. Still, to consider the students of lower abilities, he would teach something easier to comprehend. However, he felt he could not keep teaching simple concepts because "The students of higher abilities may feel bored and unwilling to listen." Mr. Wu stressed he never gave up on the students of low abilities. Instead, he would encourage them to learn and help them become better test-takers, for example, by telling them how to guess the possible right answers. He said, “Although I do not expect them to improve their performance much, they need basic scores to have a more promising future.”

To Mr. Wu there was little time for flexible use because mathematics teachers of the same grade level would work together to decide the textbook and schedule of teaching and testing. Because Mr. Wu had to follow the planned schedule and cover much content, his instruction was mainly lecture-based. Due to the time constraint, he could not employ multiple evaluation methods. He usually took ten to twenty minutes to have a pencil-and-paper test before starting a new lesson, or he would ask students some questions during instruction to understand their learning progress. However, Mr. Wu indicated his instruction was somewhat different from other mathematics teachers’. Instead of solely presenting problem-solving procedures and giving the students many tests to practice the taught concepts, Mr. Wu emphasized guiding students to solve problems by gradually building up their prerequisite understanding. He described,

> My way of teaching math is different from other teachers’. I usually use simple words to describe an abstract concept, and I do not follow the textbook step by step, word by word. For example, if a problem consisted of three main concepts, I introduced the three concepts first. Then, I would ask students to construct a new result based on the three concepts. I preferred guiding my students to solve a problem, and it took much more time. Therefore, I gave my students fewer tests.

Regarding his past technology usage, he used computer software Geometer's Sketchpad to teach the tenth-grade trigonometric function. Most students were confused with the concepts and it was tedious to draw the graphs. After explaining the related concepts, he would use software for drawing the graphs and presenting the results of functions. For example, one purpose of drawing trigonometric graphs was to help the students understand the periodicity of sine and cosine functions. Mr. Wu thought computer graphic software could beautifully present the fluctuations of the functions and interest the students. Mr. Wu would demonstrate how to operate the software to draw the graphs, and then he would ask the students to draw the graphs themselves. Because the classes he taught two years ago also attended the E-Book project, each student had a tablet PC and could use the software to draw graphs during class time. As for the students who did not join the E-Book project, Mr. Wu believed if the students were interested in the assignment, they could use the software themselves at home or in the computer labs after school.

However, Mr. Wu only used educational technology for teaching certain lesson units of the tenth-grade curriculum. He explained,

> The tenth-grade is not close to the joint exam yet so we can find some time to use computers in the instruction. We have much content to cover at the eleventh-grade, and therefore we cannot find time to integrate technology. Using technology to teach the twelfth-grade students is barely possible because they face the urgency of the exam.

Mr. Wu thought if he integrated technology well in teaching the tenth-grade students, the students could apply their learning experiences to solve mathematics problems with the software after they moved to higher grade levels. He said, “We foster students’ ability for using educational technology when they are at the tenth-grade, and then we need not spend time teaching them the knowledge and skills again.” According to Mr. Wu, the students interested in using the software to learn mathematics concepts would do the practice at home while those who were not interested or less capable were unable or unwilling to find time engaged in such study.

While viewing educational technology as a means to motivate students in learning mathematics, Mr. Wu did not think technology was beneficial for improving student performance in the examinations. He agreed some students might want to apply for departments relevant to mathematics in their further college or graduate study because of his technology usage. However, the main purpose of his technology integration was to present mathematics concepts in an interesting and flexible way rather than improving test scores. Mr. Wu said using educational technology could even lower students' scores in the examinations because technology integration took much time and students would be too excited to settle down to solve problems. He was concerned educational technology could motivate student interest and encourage the students to spend more time exploring mathematics concepts with technology but they might become unwilling to conduct serious learning tasks (Collins, 1996; Lowyck & Elen, 2004; Olson & Clough, 2001). He expressed,

> Using technology takes much time and excites students. Mathematics focuses on theoretical aspects. You need to calm down and work on a problem or a theorem. Through pondering and researching on a problem, you learn math. To do this, we don't need computers. Computers cannot help us think, and math emphasizes on thinking. To teach math, a pen can be the sole means.

Even though he did not often use technology in teaching mathematics, Mr. Wu was interested in learning more about educational technology. He would try to attend professional development programs held inside and outside the school, and Mr. Wang would sometimes introduce him new software and materials related to mathematics teaching. From these experiences, he developed different ideas helpful for technology integration. Yet, the discussions among the mathematics teachers were mainly about content or pedagogy, for example, why students could not understand certain questions. Mr. Wu thought "different teachers have different teaching approaches" so he tended not to discuss how to implement technology integration with his colleagues. Furthermore, he did not feel he received enough support to improve his study on technology integration. He said, "Had our school provided me more support and encouragement, I would have made a difference and even motivated other math teachers to be involved in the practice of technology integration."

Teacher beliefs and technology usage

At the beginning of the interview, Mr. Wu said that traditional instructional approaches worked well for helping students to score higher in the joint examination but he did not enjoy nor approve such instruction. He said,

> The traditional instruction method of keeping lecturing and testing students may be effective to prepare students for the joint exam. However, it is neither my ideal instruction nor what I want to do. This kind of instruction is really painful to students as well as teachers. Most teachers use the traditional ways to teach because we have no other choices. The math instruction in Taiwan cannot really increase student ability of learning math because such ability should be fostered patiently.

His description of ideal math instruction was well matched to concepts of cognitive constructivism and social constructivism including metacognition, prior knowledge, knowledge transfer, scaffolding, and peer learning. He described,

> I definitely want to teach students how to learn math. Moreover, they can easily learn the basic concepts and apply these concepts to solve problems. During the learning process, I hope they will discuss their questions with me and peers. I may confirm their findings or provide alternatives to solve problems. This is my ideal instruction. I think learning math in this way can alleviate students' math phobia.

Mr. Wu further explained how the instruction aiming at the joint examination was incompatible with his ideal instruction. He explained,

> My ideal instruction is to teach some important concepts. These basic concepts can actually combine together to form a more complicated concept. Right now, the exam guides our instruction. If the exam can be changed, I can teach students the important and basic concepts distinctly and effectively rather than asking them to learn lots of useless stuff. Being able to apply basic concepts flexibly is enough, and then they can solve advanced math problem years later. Simply trying to handle the exam is too mechanical, and it should not be the goal while learning math.

Also, Mr. Wu described his own learning experience to stress the importance of self-regulated learning. Mr. Wu said he learned mathematics by studying the textbooks himself when he was a high school student, and he felt "What I learned from my teachers' instruction was far less than what I learned from my own studying and thinking. Therefore, he believed in the idea of encouraging students to learn on their own. He argued mathematics teaching should focus on student interest and, "If they are interested in learning math rather than solely handling the exam, they can have the ability to learn and be confident with their performance in the exam." Mr. Wu added, "Students' willingness to learn is the most critical element of instruction." He concluded with the responsibility he took as a teacher, "If students are willing to learn, I will try my best to teach them; however, if they don't want to learn, I can do nothing about it."

Throughout the interview, Mr. Wu mentioned the importance of student interest and intention to learn and think several times. These aspects reflected his conception of learning mathematics and hence affected how he perceived the role of educational technology in teaching mathematics. He stated,

> Math is not a new thing. The math concepts we are learning were mainly discovered by theorists one or two hundred years ago. I don't think to understand the old concepts we need new means. The theorists thought and proposed the concepts so the point is thinking itself. They had the interest and intention, and they made efforts in thinking. Similarly, if our students have the intention, they can learn math well.

Inconsistently, Mr. Wu did not think his students could learn how to solve problems on their own because "The students are used to being forced to study by teachers." Also, Mr. Wu felt many teachers gave the students lots of tests and assignments so the students had to spend much time doing what they were required to do. He expressed, "I could barely cover the content, not to mention allowing students some time to conduct projects or write reports." His concern was, "The students appropriated much time which should be used for studying basic subjects such as Chinese, English, and mathematics to search for information online and write reports for other subjects." Understanding that students were under much pressure, Mr. Wu tended not to ask the students to work on projects after school, and his class time was mainly devoted to content coverage.

Not only the time pressure but also Mr. Wu's beliefs about mathematics learning affected his perception about technology integration. Because Mr. Wu believed learning mathematics focused on thinking and "educational technology is pretty static while math is dynamic," he considered, "Using educational technology to present the various and original features of math is very difficult, if not impossible." Mr. Wu felt educational technology was not flexible enough to help the students analyze and solve all kinds of mathematics problems. Hence, an important concern of his technology integration was whether the characteristics of a lesson unit could be presented appropriately with technology. "For instance," he said, "computer software can find whether a number is a prime number but I think this function of little use." He continued, "What is important is the concept behind this function." While recognizing technology could be helpful to motivate students and visualize some abstract concepts, Mr. Wu disagreed educational technology could improve mathematics teaching for every lesson unit. "The promotion of technology integration nowadays makes people decide mistakenly that using technology is helpful for teaching every math concept," he said, "and I personally feel this is misconception." In the study by Manoucherhri (1999), about two-thirds of the surveyed high school math teachers thought using computers for students to explore mathematics concepts could be more appropriate for elementary or middle school students. Likewise, Mr. Wu suggested integrating technology with mathematics teaching might be more appropriate for teaching elementary mathematics because "the content is simpler and easier to be visualized with technology."

In addition to the content appropriateness, Mr. Wu felt the challenge of integrating technology with mathematics teaching caused the reluctance of most mathematics teachers to conduct the integration. He analyzed,

> To conduct technology integration, teachers need knowledge about educational technology and deep understanding about math concepts to dissect mathematics concepts and design appropriate ways to present the concepts. Most teachers may be timid to undertake the new approach because it takes time to study and think. When teachers do not have enough time to study, they will not want to take risks and are not interested in doing it.

Mr. Wu was fully aware that technology integration demanded the teachers to possess strong knowledge background including content knowledge, pedagogical content knowledge, curricular knowledge (Shulman, 1986, 1987), and knowledge of using educational technology. Although Mr. Wu rarely integrated technology with mathematics teaching given the pressure of covering required content and preparing students for the joint examination, he recognized technology could be helpful for improving mathematics teaching in various ways. He suggested, "Because our instruction is guided by the exam, to achieve extensive technology integration needs changes to the college admission system." He continued,

> If the conditions change, educational technology may assist teachers and students in many ways. For example, math is more about theories. Theoretical concepts are invisible, and computers can help us generate complicated graphs or verify some theories easily. Also, computerized tests can be very helpful.

To Mr. Wu, for mathematics teachers and the students to benefit from technology integration, substantial changes should be made in the college admission system. However, he commented, "I think it is very difficult to change." For instance, each class was ranked with other classes of the same grade level. "Without agreement on beliefs and actions," Mr. Wu concluded, "individual teachers are vulnerable while facing pressure from parents, self, and administrators."

SUMMARY

With the method of qualitative case study, this study investigates the relationships between teacher beliefs and their technology integration. The referred beliefs include teachers' pedagogical beliefs and their beliefs about the applicability of technology in achieving their instructional purposes. Moreover, how various contextual factors and the beliefs are interrelated to affect the decision-making processes and teaching practices is addressed. From a broader perspective, the participants were constrained by the educational policies, the college admission system, and the school organization. On one hand, the government and school administrators had been promoting technology usage in instruction by allocating funding to establish equipment and offer opportunities of professional development. On the other hand, the College Joint Entrance Examination still influenced the instruction profoundly. According to the curriculum standards announced by the Ministry of Education, the teachers chose the textbooks, planned the schedules, and decide the assessment methods.

Because a primary goal of the school was to prepare students for the joint examination, teachers of all subjects faced various barriers to putting their ideal instruction into practice. For instance, teachers who taught tested subjects had to cover much content in a short period of time and handle the large diversity of student performance in each class. Although teachers teaching untested subjects could be more flexible in deciding instructional materials, ways to implement the instructional plans, and evaluation methods, they might have difficulty in motivating students because of the emphasis on the joint examination. Indeed, compared with the teachers in many other schools, the participants could have access to more resources and equipment. However, most participants reported the shortages of equipment and support, and the opportunities for professional development and available example of technology integration did not allow the teachers to grasp critical concepts about how to combine instructional theories with technology to improve teaching and learning fundamentally. The instruction of most teachers remained teacher-centered and lecture-based. Furthermore, the most popular way of technology integration was using a computer, an LCD projector, and presentation software to support lectures.

Nevertheless, given similar conditions and with similar equipment and support, the teachers holding different beliefs did perceive their educational purposes and barriers to ideal instruction and technology usage differently. Even though inconsistency between reported beliefs and actual practices occurred sometimes, the technology integration of most participants reflected their beliefs accordingly. To highlight the interrelationships among teacher beliefs, various contextual factors, and practices of technology integration, four participants were chosen as representative cases for presenting the findings of this study. The pedagogical beliefs of Miss Huang were consistent with the concepts of constructivism, and she focused on fostering students' abilities for critical thinking, self-regulated learning, and effectively communicating their ideas with others. Viewing educational technology as means to improve teaching and learning, she made efforts to keep experimenting on how to integrate her ideas with the instruction. For example, educational technology was used for supporting project-based learning and providing an environment for open discussion. Although she faced different challenges such as large class size, students' unwillingness to cooperate, heavy workload, and the busy schedule, Miss Huang considered these challenges a necessary evil while during realizing her ideas. Taking positive attitudes toward technology integration, Miss Huang remained cautious about how and when to integrate technology. She did not often use technology in her instruction unless traditional methods could not fulfill her instructional goals. Not being over-optimistic about technology usage, she insisted more attention be paid to how to substantially change teacher beliefs and practices rather than simply replacing old means of teaching with technology.

To Mr. Lee, educational technology had become an indispensable element of his instruction. Mr. Lee believed teachers should change as students change so he kept modifying his instruction according to student reaction. Therefore, integrating technology with his instruction represented his adaptation to the changing environment. Adopting approaches consistent with the concepts of cognitive apprenticeship and social constructivism, Mr. Lee encouraged the students to interact with him and peers. In Mr. Lee's class, educational technology was mainly used for presenting curricular content. He decided to create a whole package of slides, and therefore he could reuse the created materials which would only require some minor changes in the future. Technology usage reduced the frequency of using the blackboard, but Mr. Lee and the students still used the blackboard often because of the flexibility in demonstrating problem-solving processes and promoting discussions. At that time, Mr. Lee was satisfied with his instruction and technology integration and had not intended to make further change but he expressed the willingness to adjust his practices to meet the expectations of parents and students.

Ms. Chen distinctly expressed the main purpose of her instruction was to prepare students for the joint examination. Efficiency of covering the content carried a lot of weight in her decisions about technology integration, because there were many teaching materials to cover and she believed the more she covered the more the students would learned. Regarding the advantages of technology usage, while recognizing the benefit such as highlighting important concepts and sharing works with peers, the main reason Ms. Chen enthusiastically approved technology usage was she could teach much more content by saving the time of writing and erasing content on the blackboard. However, the reason she stopped using technology for instruction was also due to the concern of efficiency. Compared with using slides, giving the students handouts and then explaining the parts the students did not understand was even more efficient. Also, without necessary equipment installed in the twelfth-grade classrooms, Ms. Chen felt bringing students to a computer lab and managing their behavior and other unexpected problems was very stressful. Furthermore, there was discrepancy between Ms. Chen's reported beliefs and her actual practices.

Similar to most mathematics teachers, Mr. Wu rarely used technology for teaching mathematics. Although Mr. Wu considered preparing the students for the joint examination an important goal of his instruction, he did not appreciate the commonly adopted instructional strategies of continuing to lecture and test students. Instead, he emphasized the importance of building on student understanding to foster their problem-solving and self-regulated learning. He believed mathematics learning focused on thinking and it did not need fancy technology which might motivate students but could also distract them. He would use educational technology to teach the tenth-grade because the grade level had less content to cover and did not face the pressure of the joint examination yet. Mr. Wu figured teaching the students how to use mathematics software at their tenth-grade provided the experiences of using technology to learn mathematics and the students could transfer the learning experiences to learn other mathematics concepts when they moved to higher grade levels. Therefore, while being interested in learning educational technology himself, Mr. Wu had not used technology for mathematics teaching for two years.

In the next chapter, the similarities and differences across the cases would be discussed in detail. Also, referring to relevant literature and the findings of this study, I would interpret how these findings answer the research questions.

Chapter 5: Discussion and Recommendation

This chapter discusses the results of the study, as well as implications and recommendations for future practice and research. The discussion section begins with the general technology usage of the school followed by how the teachers' beliefs affect the instruction and technology integration, the contextual factors surrounding the teachers that influence their practices, and the difficulties of changing beliefs and practices. The section on implications for future practice includes suggestions for designing professional development programs, for organizing school settings, and for providing necessary support for teachers. Finally, six categories of suggestions for future research are illustrated.

DISCUSSION

This study investigates the technology integration of Taiwanese high school teachers, and the investigation focuses on three research questions: (1) How do teachers in Taiwan incorporate technology into their instruction? (2) How do the teachers' pedagogical beliefs and beliefs about the potential of technology for achieving their instructional goals influence their practices? and (3) What contextual factors influence teachers' beliefs and their integration of technology? In general, most teachers in the school were like Mr. Lee and Ms. Chen who used technology to present instructional content and anchor interaction. In spite of my expectation, teachers' pedagogical beliefs and beliefs about technology integration were not primary factors influencing technology integration. Instead, comparative analysis indicates primary mitigating factors were teachers' concerns regarding obstacles to technology usage in classroom. Nevertheless, teachers' pedagogical beliefs and beliefs about how technology could help them achieve their instructional goals did affect their perception and practice of technology integration.

General technology usage

The most common technology usage in the school was the use of LCD projectors and presentation software to present information. According to Banathy's (1991) comparisons between focusing on instruction and focusing on learning, although some participants occasionally presented learning tasks to engage students in active exploration, in most classrooms, the focus was on instruction. Teachers, not students, were the actors in the classrooms. The primary responsibility of students was to pay attention to their teachers. The classroom environment and teaching aids were organized in ways to support teaching rather than learning (Banathy, 1991). The main purpose of using technology in the school was to support teacher-centered, lecture-based instruction, and such usage was consistent with the arguments that complex technologies have relatively little influence on most teachers' daily teaching; that teachers often prefer simple, durable, and reliable technology to improve the efficiency of teaching and instruction planning rather than profoundly transforming their work and roles (Putnam & Borko, 2000; Tyack & Cuban, 1995).

Similarly, Clark & Yinger (1979) indicated that teachers would feel an instructional activity or approach undesirable if it was too difficult for students or too demanding for the teachers. Integrating technology with instructional approaches which are simple and familiar to both teachers and students is therefore preferred by most teachers. Teachers tend to incorporate technology into their instruction in ways to reduce their workload and to maintain their traditional roles as a teacher. Therefore, the most popular applications of technology are to save teachers time and energy, to enhance instructional routines, and to allow teachers to remain in control over their daily practices (Cuban, 2001; Hodas, 1993; Putnam & Borko, 2000; Tyack & Cuban, 1995). Most participants confirmed that they used various technologies for personal purposes, for instruction planning, and for administrative work, but very few of them viewed technology as a means to achieve instructional goals other than covering curricular content, preparing students for examinations, and highlighting important parts to grip student attention.

Teachers shared the viewpoint of Ms. Chen and Mr. Wu on prioritizing content coverage and examination preparation, seeing technology as a powerful tool. However, at times they considered technology a distraction that prevented their students from reaching instructional goals. Zhao & Frank (2003) indicated that the purpose of technology usage for most teachers is to meet their direct needs, to maximize their benefits and to minimize their costs, and the teachers do not want to spend much time learning how to use the technology or to fundamentally change their instruction. Regarding the willingness of spending time learning how to use technology, most participants considered technology integration an unavoidable trend so they felt the need to improve their general computer knowledge and skills. However, just as Zhao & Frank (2003) argued, the cost-benefit consideration played a critical role in most teachers' decision making.

Therefore, Mr. Lee decided to spend a whole summer digitalizing all teaching materials so he could be at ease in the future. His technology usage supported lectures and interaction with the students without demanding much effort to create or revise teaching materials. Moreover, although Ms. Chen was enthusiastic about how efficiently she could cover curricular content with technology and was willing to spend much time creating slides and teaching materials, she decided to stop using technology when she found that the created slide could not be reused, and that giving students test papers and handouts directly could save even more time and efforts. Meanwhile, Mr. Wu felt that integrating technology with instruction could motivate students but technology integration might not be useful for improving student performance in tests and it might disturb students' concentration in learning mathematics. Mr. Wu was interested in learning how to use educational technology and he devoted time and energy to this, but he only used technology for teaching certain lesson units of the tenth grade.

Perhaps most teachers decide to incorporate technology into instruction to reduce workload and to improve efficiency. However, Hokanson & Hooper (2004) argued that the purpose of using technology is not to make education easier but to make learning more effective, and meaningful learning requires an investment of significant time and effort. Likewise, teachers need to invest considerable time and effort to design and implement meaningful technology integration. When technology integration is viewed as a practice remotely different from the existing school culture and familiar practices, teachers may have no motivation to incorporate technology into instruction. Or, their teaching may fall back to novice teaching levels during the integration process. Even competent teachers may struggle with the incompatibility between proposed and existing practices (Pierson, 2001; Max et al., 1994; Sandholtz et al., 1997; Zhao et al., 2002). Hence, most participants expressed no intention to integrate technology in ways to substantially change teaching and learning. Simply adopting basic applications of technology in the classrooms, they had faced various obstacles.

For example, as the description of Ms. Chen and Mr. Lee makes clear, the novelty and unanticipated breakdowns of technology could frustrate teachers. They were constantly concerned with issues such as classroom management, resource management, interruption of the instruction flow, and frustration resulting from wasting time on recovering from mistakes (Sandholtz et al., 1997). Shavelson & Stern (1981) explained that during interactive teaching, teachers' first concern is usually to maintain the flow of learning activities, so they make efforts to manage the complexity of a learning environment and to make it simplified and predictable by planning instruction in advance. The plans guiding the instruction are usually routinized. On one hand, some participants reported that pre-created slides could be used as instructional plans to orient teaching so they felt prepared and comfortable. On the other hand, technology integration introduced unpredictable variables which could bring interruption and disturbance to the classroom. To take advantage of technology usage and also to reduce tension and anxiety, most participants chose to maintain the basic integration mode, which was using LCD projectors and presentation software to support the familiar instructional approaches.

To those teachers who are competent and willing to combine technology with creative instruction design to foster students' critical thinking, self-regulated learning, and collaborative learning, effective technology integration is still a challenging task. For example, during the integration process, teachers may face the dilemma of spending much time fostering student autonomy or covering the content of the specified curriculum (Max et al., 1994). Teachers such as Miss Huang who wanted to conduct instructional activities such as project-based learning with technology could do so once or twice a year, because such activities took much time and the pressure of covering enough content prevented the teachers from flexible time management. The approaching joint examination forced all the twelfth-grade teachers to focus their instruction on content coverage and examination preparation, and the teachers therefore hesitated to integrate technology with time-consuming learning tasks.

Technology integration is not equivalent to successful instruction and meaningful learning (Hokanson & Hooper, 2004; Lowyck & Elen, 2004). Postman (1996) also stressed that computers will not solve any school problem which cannot be solved without computers. It is obvious that teachers like Ms. Chen who viewed technology as a means to efficiently support lectures and knowledge transmission tend not to reconsider their instructional approaches and may instantly stop using technology because of cost-benefit considerations or the pressure of high-stake tests. Therefore, more emphasis should be placed on the capacity of technology to improve instruction than on technology itself because changing the means of instruction delivery will not improve instruction quality (Hokanson & Hooper, 2004). The technology usage of traditional exemplary teachers may not facilitate effective instruction unless the teachers consider technology in the context of teaching and learning rather than as a peripheral tool (Pierson, 2001).

Even though the administrators made efforts to acquire technology equipment and to provide professional development programs to encourage technology integration in the school, without the experiences of observing good examples of technology integration, the teachers had very limited concepts about how technology could be integrated with creative instruction design to foster student understanding. Niederhauser & Stoddart (2001) argued that although current efforts to encourage technology integration imply using technology will promote constructivist instruction, technology does not contain any pedagogical orientation. Schools may promote technology usage without an appropriate pedagogical framework to support the implementation, and therefore the technology-based innovation cannot lead to a substantial change in curriculum and instruction (Ferneding, 2003). Most participants of this study were regarded as frequent and even pioneering users of technology, but their technology integration did not fundamentally change their instructional approaches. Even for those teachers who were willing to conduct activities consistent with concepts of constructivism, lecture-based instruction took a huge proportion of class time.

Accordingly, the findings of Ertmer et al. (2001) demonstrated that the perceived and practiced exemplary technology usage was not necessarily consistent with the best practice proposed by literature. Instead, the exemplary teachers of technology usage presented a hybrid of proposed visions and realities in current classrooms. The findings of Cohen & Ball (1990b) may provide a reason why some teachers in the school integrated technology to support lecture-based instruction as well as constructivist activities. Cohen and Ball indicated that teachers may overlook the contradictions between old and new policies and view two sets of instructional approaches or materials derived from different theoretical foundations as compatible. Many teachers may blend new practices with old concepts and pedagogy because they are too busy implementing policies to notice the inconsistency. Teachers are often expected to be responsible for policy implementation even though practices of the past and present may be incoherent or even conflicting. Therefore, being encouraged or forced, teachers in the school might implement the policy of integrating technology without noticing the inconsistency among their practices and the proposed ideas.

Although the perspective that teachers have to implement policies and that classroom life is too complicated for them to reflect on their practices prevents teachers from being blamed for the incomplete implementation of an educational innovation, Richardson (1990) cautioned that these perspectives also reduce the credibility of teachers to make autonomous decisions. The findings of this study indicated that teachers did not passively implement the policy of technology integration without making deliberate choices. In fact, the teachers made decisions about their instruction and technology integration based on their pedagogical beliefs and beliefs about how technology might help them put those beliefs into practice.

Teacher belief and technology integration

Many researchers recognized that the teacher is a critical element in deciding whether technology will be integrated with instruction successfully (Bitner & Bitner, 2002). The teacher interprets and translates a curriculum into classroom activities, and the teacher decides what, how and why students should learn (Olson & Clough, 2001). Teachers' knowledge and beliefs about the development of learning environments and about classroom management are closely related to their knowledge and beliefs about how students learn and how their teaching can foster student learning (Borko & Putnam, 1996). Therefore, teachers' knowledge and beliefs about how technology should be used are connected with their pedagogical beliefs. The findings of Niederhauser & Stoddart (2001) indicated that most teachers use technology in ways consistent with their personal beliefs about curriculum and instruction. For example, teachers who hold teacher-centered beliefs tend not to use technology to support student-centered instruction.

The findings of this study confirm that teachers' pedagogical beliefs affected their technology integration. Holding beliefs consistent with concepts of constructivism, Miss Huang made efforts to foster students' critical thinking, self-regulated learning, and skills of collaboration and communication by engaging students in activities such as project-based learning, peer evaluation, and online discussion. Technology provided a tool for her and the students to share ideas and products. To Mr. Lee, social interaction in class was a critical element to foster student understanding. Adopting instructional approaches such as modeling, coaching, scaffolding, and collaborative problem-solving, Mr. Lee used the presentation function of technology to highlight important concepts, to demonstrate problem-solving procedures, and to facilitate interaction between himself and the students. Efficiency was the top priority to Ms. Chen, and she believed that the more content she covered, the more her students would learn. Therefore, she considered using slides to present curriculum content the most efficient way to accomplish the goals of content coverage and examination preparation. Emphasizing students' genuine understanding of important concepts and their willingness to learned, Mr. Wu used mathematic software to concretize abstract concepts and to motivate student interest.

Not only teachers' pedagogical beliefs affect their decisions of technology usage; beliefs about technology and its potential for meeting their instructional goals play important roles in influencing technology integration. The findings of Windschitl & Sahl (2002) indicated that teachers evaluate the affordances and constraints of technology based on their beliefs about students and their needs, about what appropriate teaching practices in certain subject areas should be, and about what levels of control they students should have. In sum, teachers' interrelated belief systems decide what is appropriate or possible in their classrooms. For instance, Miss Huang regarded her technology usage as a compromised improvement because of the discrepancy between her ideals and realities. Issues such as students' inflexible learning habits, inappropriate assessment methods, available equipment, and lack of examples of effective technology integration caused the incomplete realization of her ideals. Miss Huang believed that technology integration should focus on how to integrate technology with innovative instructional approaches rather than using new technology to support old teaching methods. Considering that meaningful technology integration takes time, Miss Huang chose not to use technology when traditional ways of teaching could fulfill her instructional purposes.

In Mr. Lee's case, although technology had become an indispensable part of his instruction, he had no intention of integrating technology beyond the familiar practice of presenting content with the projector. Satisfied with his existing practice and students' reactions and concerned with the difficulty for him and his students of accessing the necessary equipment, Mr. Lee did not plan to incorporate new technology applications to facilitate group discussion and interaction, which he regarded as a main purpose of his instruction. Ms. Chen emphasized the efficiency of covering more content and viewed technology as a powerful tool to meet this goal. However, rather than explore the use of technology for more than knowledge transmission, Ms. Chen decided not to continue her technology integration after experiencing the inconvenience of accessing the necessary equipment and support and finding other efficient ways to cover the curriculum. Unlike most mathematics teachers, Mr. Wu was interested in integrating technology to motivate students and in studying new methods of mathematics teaching with technology. Yet he was unsure about the potential of technology for improving student performance in tests and for fostering students' appropriate habits and attitudes in learning mathematics, so his technology usage was restricted to the infrequent demonstration of drawing function graphs with mathematics software.

Moreover, teachers' beliefs in their own abilities and knowledge affect their technology integration. Nisan-Nelson (2001) suggested that the confidence level of a teacher in his or her own problem-solving ability and the way a teacher approaches or avoids a problem may influence the level of technology integration. For example, teachers like Mr. Lee and Ms. Chen who are not confident in their ability to solve technical problems and are uncertain about the availability of instant support may avoid bringing students to a computer lab or changing their familiar ways of technology usage. Ross (1995) used Bandura's theory (e.g., Bandura, 1977, 1986, 1993) to explain that teachers with higher self-efficacy expect their success in improving student learning and tend to adopt challenging tasks and higher standards for themselves and for their students. These teachers will persist in making efforts while encountering difficulties even when the obstacles may be beyond their control. They tend to encourage student autonomy and impose less control over student learning and classroom management. The description of teachers with higher self-efficacy agrees with the findings related to Miss Huang. She believed that a teacher capable of independent thinking would be willing to take risks and overcome obstacles to improve their instruction. Considering difficulties and constraints during her technology integration inevitable, Miss Huang developed strategies to advance her practice with technology and to encourage self-regulated learning and collaboration among students.

Some teachers may believe they are unable to perform certain practices although they understand what possible improvement could result from those practices. However, some practices may be within the reach of teachers but they do not believe those practices will have substantial impact (Ross, 1995). For instance, without technical support, some participants expressed the difficulty of incorporating technology applications beyond word processing and PowerPoint presentations. Publishing web pages was one example. However, teachers do not always resist an innovation because of their fear or concern about their limited capabilities to conduct a new practice. Instead, they may feel the proposed practice is not feasible according to their beliefs and experiences (Ferneding, 2003). Hence, most participants reported high agreement levels on constructivist concepts, but they considered those concepts almost impossible to implement due to issues such as time pressure and class size. Those teachers might identify with concepts such as student autonomy, active knowledge construction, and collaborative learning, but at the same time, they believed that maintaining classroom order and covering curricular content were their responsibilities. With limited time to arrange learning activities, the teachers often struggled with conflicting beliefs (Max et al., 1994).

As pointed out by Zhao et al. (2002), successful technology integration is related to teachers' perception. When teachers view technology as a means to achieve their instructional goals and when they incorporate technology in ways that seamlessly connect with their pedagogical beliefs, successful technology integration is much more likely. Since teachers' beliefs and attitudes have a strong influence on their technology integration, these beliefs must change to permit technology usage (Russell et al., 2003). Nevertheless, simply investigating teachers' beliefs may not enable researchers to anticipate how they will integrate technology with instruction. Davis et al. (1993) proposed that more research needs to concentrate on how teachers put their beliefs into practice under the constraints caused by the complexity of classroom life.

Teacher belief and contextual factors

The findings of this study indicate that teachers' pedagogical beliefs and beliefs about the potential of technology did affect their technology integration. However perceived obstacles to usage were primary factors influencing teachers' technology integration in classroom. When teachers are required to implement a new curriculum or instructional approach, they tend to interpret and modify the promoted practice based on their own knowledge and beliefs. Teachers' existing knowledge and beliefs decide what aspects of a reform to focus on and how to interpret and implement these aspects in their instruction (Borko et al., 2000; Cohen & Ball, 1990a, 1990b; Richardson, 1990). Hence, the promoted practice could be different from the realized practice because the teachers adapt the promoted practice to the particular situations of their classrooms and to the characteristics of their students. Furthermore, under similar situations, teachers at the same school but holding different beliefs perceived the contextual factors or barriers to technology integration differently.

Ertmer (1999) indicated that first-order barriers--for example, insufficient equipment, time, training and support--can definitely hinder technology integration, but the strength of second-order barriers such as teacher belief and existing practices may alleviate or aggravate the influences of first-order barriers. For example, without adequate resources and support, some teachers could give up using technology in their instruction while some teachers with high self-efficacy and positive attitudes toward technology integration could make efforts to overcome the barriers. The case of Miss Huang confirmed this argument: she viewed the challenges as necessary processes of improvement rather than difficulties. Nevertheless, most of the time, beliefs in various aspects interact to decide how teachers perceive the contextual factors. Therefore, teachers' self-efficacy will be affected by student achievement only when they attribute student learning to their efforts, and these teachers incline to reflect on how their instruction has impacted student learning and take responsibility for their instruction (Ross, 1995). For instance, Mr. Lee reported that seeing students improve their performance and receiving their appreciation motivated him to gradually change his instruction. Also, Ms. Chen was willing to spend much time creating slides because she believed her efficient technology usage helped students learn more.

While teachers' beliefs affect how they perceive the contextual factors surrounding them, they may develop, change or strengthen beliefs while interacting with these factors. In fact, teachers' beliefs and contextual factors may be mutually affected. For example, some teachers' traditional pedagogical beliefs which value knowledge transmission will be reinforced by a school structure which motivates students with grades of pencil-and-paper tests (Blumenfeld et al., 2000; Hung & Koh, 2004). Most participants had developed the belief that scoring high on the joint examination was an important goal of high school students in Taiwan since they were students themselves. Based on this belief, they employed appropriate resources, instructional strategies and technology applications to achieve this goal. Also, the school settings, evaluation methods, and attitudes of other stakeholders such as students, parents, and administrators all verified and strengthened the belief.

Sometimes, certain factors or constraints of the environment do not support teachers' beliefs in their purposes as teachers. To reduce the tension between their purposes and constraints of the environment, teachers may lower their standards or decide not to accomplish all goals. Certain coping strategies, appropriate or not, are developed to assist teachers to handle difficult situations. For example, while facing a great diversity of student achievement, teachers may view some students as not teachable (Buchmann, 2003). Similarly, most participants claimed that their instruction focused on the majority of students whose abilities were at the median level because of the large class size and the diversity of student achievement. Feeling comfortable or not, the teachers paid much less attention to the learning needs of students of low achievement.

Perceived contextual factors

Although teaching is usually regarded as an intentional activity, not all teaching activities are based on teachers' intentions or beliefs because the environment surrounding the teachers has a strong influence on teachers' decision-making (Lowyck, 2003). Teachers' decisions about instructional strategies are based on different information and concerns, including information about students, their beliefs or instructional purposes, the characteristics of learning tasks or curriculum, and the constraints and support of the instructional situations (Ball & Cohen, 1996; Borko et al., 1979; Calderhead, 1987). Although teachers' instructional decisions may be directly influenced by characteristics of students, subject matter and instructional goals, factors outside classrooms such as educational facilities, material resources, school politics, pressure from administrators and parents, and professional development may also affect their decision-making. As mentioned in the second chapter, numerous studies have investigated the contextual factors that affect teachers' decision making during the process of technology integration, but the value of such studies will be limited without identifying the characteristics of the factors, the applied contexts, and the relationships among the factors (Zhao et al., 2002). The following discussion will focus on the contextual factors influencing the participants' beliefs and technology integration in the context of Taiwanese high schools. Interrelated factors may be presented simultaneously because their influences on the participants' decision-making are not linear and isolated.

The College Joint Entrance Examination

Although the Ministry of Education has been making efforts to alleviate negative effects of joint examinations by undertaking various educational reforms, the examinations have tremendous influence on the instruction and assessment of most Taiwanese high school teachers, and the teachers are usually reluctant to implement creative but time-consuming activities. Ingram, Louis, & Schroeder (2004) considered the idea that teachers collectively have to be responsible for students' learning outcomes, both novel and controversial. Teachers used to think that if they delivered the curriculum, it was the students' responsibility to do the learning. However, most high school teachers in Taiwan, especially those who teach academic subjects, take the official data reporting on students' learning outcomes seriously because the data represent the competency of students, teachers themselves, and schools. As argued by Buchmann (2003), teachers often prioritize students' needs, and they are aware of the inappropriateness of making decisions about instruction, curriculum and classroom organizations without comprehensive consideration. Most teachers do not persist in their own opinions without considering other stakeholders' perspectives (Calderhead, 1987).

Under the pressure of preparing students for high-stakes tests, teachers may be torn between their ideal instruction and covering the content which may be related to the items on the tests (Pellegrino, 2004). The teachers may compromise their ideal instruction to meet the needs and expectations of students, parents, and administrators. Consequently, the curriculum and instruction may be narrowed down to examination preparation, and student learning may be restricted to memorization and repetitive practice. Regarding technology integration, as Mr. Wu indicated, using educational technology in instruction could have no improvement in students' test scores. Even though most participants recognized the advantages of using technology to motivate students and to cover more content, none of them considered technology integration useful for preparing students for joint examinations. The approaching joint examination also resulted in the reduction or termination of technology usage in the twelfth-grade.

Nespor (1987) argued that an essential condition for changing teacher beliefs and practices is the existence of alternatives to replace the old ones. Teachers may interpret an innovation based on their existing beliefs and practices and be unaware of the necessity of changing the beliefs and practices. The proposed technology integration encourages student-centered instruction, and such instruction may challenge the traditional pedagogical beliefs of some teachers who are uncomfortable with relinquising control. The teachers refuse new ways of teaching because what they have been doing for years has effectively met their instructional purposes (Ball, 1990; Pfundstein, 2003; Sandholtz et al., 1997). Firmly believing in the importance of examination preparation and the limited value of technology usage in this aspect, the teachers inevitably became attached to the familiar practices they believed to be more effective in achieving the goals. They also preferred time-saving technology applications such as PowerPoint presentation to time-consuming ones such as using technology for long-term projects.

Curriculum standards, textbooks, and assessment

Mandatory curriculum standards, textbooks used by teachers of the same subject and grade level, and inflexible assessment methods were closely related to teachers' decisions about how to use technology, especially those teachers who taught tested subjects of the joint examination. Every semester, most high school teachers in Taiwan adhere to the following routines: choosing a textbook from a variety of textbooks fulfilling the curriculum standards, deciding a schedule for covering the textbook content, and taking turns to compose test papers for the three major tests. The three major tests usually account for seventy percent of the final grade, so teachers have little flexibility to include supplementary materials or employ different assessment methods. As the description of Borko & Shavelson (1990) demonstrated, teachers often view the textbook as the main source of instruction content, and they seldom change the content and structure prescribed in the textbook. When teachers plan their instruction, the focus is usually on how to present the content. Constantly relying on the textbook could be a constraint on teachers' decision-making, and it could affect the quality of education. Moreover, to effectively achieve learning goals, assessment methods should connect to instruction to reflect those goals. For example, if the instructional goal is to encourage self-regulated learning, critical thinking and multiple viewpoints, the assessment methods should emphasize self-evaluation, informative feedback, explicit criteria of evaluation, and open-ended and dynamic assessment (Shepard, 2000).

However, traditional classrooms may not encourage students to be self-regulated learners, because in such learning environments knowledge is often viewed as fixed and assessment focuses on reproducing facts (Lowyck & Elen, 2004). Therefore, rigid pencil-and-paper tests can only foster certain aspects of learning, probably the most traditional ones. Ertmer (1999) suggested that teachers need different assessment methods to evaluate learning processes and outcomes while conducting technology integration. They could use rubrics, electronic portfolios, and performance assessment to evaluate the students, and self-evaluation of students should be encouraged. Nevertheless, Hodas (1993) indicated that most technology integration focuses on transmitting knowledge to students, because the process can be evaluated easily and it is a function commonly considered necessary. Actually, standardized tests can not fulfill the evaluation needs of the teachers who want to integrate technology with original instruction design to foster student understanding. For instance, Miss Huang expressed a concern that she needed to develop appropriate assessment methods to evaluate student performance in activities supported with technology, such as open discussion and project-based learning.

Equipment and support

Although the school had more resources and equipment compared with other high schools in Taiwan, most participants reported issues of dated equipment and no easy access to necessary equipment and support, especially the teachers who taught the twelfth-grade. Zhao et al. (2002) differentiated between access and easy access to equipment or support. For instance, most participants had no intention of reserving a computer lab, because there were only five computer labs for around 170 teachers to use in the school and they were uncomfortable with teaching in an unfamiliar environment. Without prompt support and appropriate maintenance, most teachers could have difficulties in handling technical problems. Hence, they did not have easy access to equipment and support.

When the participants talked about support for their technology integration, most statements were related to technical support. Besides support for acquiring and updating equipment, how to help the teachers transform their instruction to focusing on student understanding is critical. Olson & Clough (2001) argued that whether technology exists in the instruction does not influence the principles of effective teaching. Effective teaching focuses on student understanding, and it is an interactive process in which teachers employ different techniques such as questioning, waiting, listening, providing nonverbal cues to encourage thinking and to engage students in the learning activities. Therefore, during the process of conducting technology integration, teachers need different kinds of support which is beyond fixing the computers or teaching them how to operate a computer. They also need support to know how to integrate technology with their instruction to achieve effective learning and teaching (Ertmer, 1999).

While implementing an innovation, an important source of support comes from colleagues. Implementing an innovation requires teachers to learn how to do things in new ways. For teachers to apprehend new knowledge, new skills, and new beliefs, it is favorable to work with peers and exchange ideas and support rather than working alone (Fullan, 2001). Zhao & Frank (2003) suggested that influence from colleagues can be a strong incentive for teachers to change their beliefs about technology usage. Interacting with peers provides teachers with different perspectives on technology and its potential for improving their instruction. Also, observing successful examples of technology usage may change their perception and make them consider the proposed practices as actually possible (Ertmer, 2005). Except for the teachers who managed labs or special classrooms, most teaches in the school stayed in their department offices when they didn't have a class. Therefore, they could have more opportunities to interact with each other. Most participants mentioned that they sometimes shared lesson plans and teaching materials, but very few teachers considered working with colleagues on instruction design. Because there was no official meeting time every week for them to plan instruction together, if the teachers wanted to undertake a project together, they had to make a special effort to do it.

Attitudes of other stakeholders

All participants reported that they often adjusted their instruction and teaching materials according to students' reactions. Hence, students' reactions and learning attitudes definitely affected their technology integration. For instance, Ms. Chen worried that in a computer lab she could not attend to the learning status of students because of being overwhelmed by numerous distractions. Considering that students might be doing off-task activities or making no progress in learning without her attention and assistance

(Doering et al., 2003), Ms. Chen tended not to bring students to a computer lab. Also, Mr. Wu shared a concern with some researchers (e.g., Collins, 1996; Lowyck & Elen, 2004; Olson & Clough, 2001) that, although technology might fascinate students, it could prevent students from forming habits of serious learning. Believing that meaningful mathematics learning demands cognitive and emotional efforts which may be uncomfortable and that technology usage could distract students, Mr. Wu was cautious about technology usage and decided to use technology only for teaching a few lessons in the tenth-grade.

The findings of Rice et al. (2001) indicated that a significant barrier to successful technology integration is pressure from administrators and parents who barely know concepts about technology integration and constructivism, and believe that teachers should control a classroom where students sit quietly and listen to the lectures. Hence, teachers who try to combine technology with constructivist instruction may be penalized. Although the government of Taiwan proposed the concept of integrating technology to foster student understanding, a primary goal of the school was to prepare students for joint examinations. As a result, the school administrators encouraged the teachers to incorporate technology into their instruction, but meanwhile, they discouraged the teachers from conducting creative but time-consuming activities with inflexible school organization and assessment systems. Moreover, when parents expressed their concerns about some teachers' technology usage and instructional strategies, the administrators did not always support the teachers, so the teachers might be forced to resume lecture-based instruction and repetitive practice.

In fact, the teachers are important stakeholders of an educational innovation. Therefore, they need to be involved in the decision-making process regarding the implementation of an innovation, and they need opportunities to understand and discuss the theoretical foundation of an innovation and whether the underlying concepts are consistent with their beliefs and experiences (Heck & Williams, 1984; Richardson, 1990). Without such empowerment, teachers may accept or reject a practice based on their personal needs or task concerns, such as classroom management and content coverage, rather than their pedagogical beliefs. Hence, teachers tend to believe they cannot change or control their practice because of external pressures imposed from administrators, parents, or policy-makers (Richardson, 1990).

Cultures

Most studies on contextual factors affecting technology integration often stress the importance of school culture (e.g., Bitner & Bitner, 2002; Blumenfeld et al., 2000; Cuban, 2001; Cuban et al., 2001; Heck & Williams, 1984; Hodas, 1993; Hung & Koh, 2004). Yet, as pointed out by Shutkin (2004), the proposals that emphasize combining constructivist instruction with technology do not mention the issues of racial, cultural and social differences. Such exclusions seem to imply the insignificance of the sociocultural differences in technology integration. Actually, racial, cultural and social differences affect how people perceive and react to the environments and events and, certainly, these issues have strong influence on teacher beliefs and practices. For instance, Berliner (2001) argued that teachers' professional development is substantially influenced by their working conditions. In different cultures and at different times, the definitions of good teachers and expertise in teaching may be different. After receiving messages about instructional goals and about good teaching, teachers interpret these messages and enact the interpretations in their practices (Ball & Cohen, 1996; Borko et al., 1979; Max et al., 1994).

In Taiwan, those teachers who can help their students score high on joint examinations are usually highly regarded. Moreover, the assessment systems implemented in most schools emphasize competition over collaboration among students and even teachers, and ranking the average scores of all classes at the same grade level causes much stress for the teachers. Accordingly, most teachers are reluctant to integrate technology with constructivist strategies. Even those teachers who are willing to explore new instructional approaches and the potential of technology for improving teaching and learning can only squeeze limited time from their busy schedules to undertake experiments and exploration. Although the government promoted technology usage and concepts aligned with constructivism, without specific guidelines and guidance, teachers implement the policies based on their own interpretation and understanding. Therefore, most participants' attitudes toward constructivist instruction were cautious, and they considered constructivist concepts ideal rather than practicable. Miss Huang expressed the concern that the implemented technology integration and educational reform were alienated from the theoretical foundations and therefore the results were often the distortion of proposed practices.

These findings do not imply that integrating technology with constructivist instruction dose not fit the needs of teachers and students in Taiwan. Instead, the findings suggest that the teachers need opportunities to investigate their own beliefs and practices and to explore new instructional strategies with technology so they can decide appropriate ways to improve teaching and learning. While undertaking an innovation, a capable teacher will adjust the innovation to the school and classroom contexts and to the needs of the people involved in the innovation. The school and classroom environments should allow teachers enough flexibility to experiment with new practices but at the same time maintain the stable implementation of the innovation (Heck & Williams, 1984).

In sum, teachers' beliefs as well as the contextual factors surrounding the teachers interplayed to affect their decisions of technology integration. Zhao et al. (2002)

indicated that how different an innovation is from the existing school culture, teaching practice and technological resources, and how much the teachers depend on the cooperation, support, and resources from others, can influence the degree of teachers' success in implementing the innovation. Even though these contextual factors may not directly determine the results of implementation, they definitely affect teachers' willingness to further and sustain the innovation.

Difficulties in changing teacher practice and belief

The findings of this study indicated that the instruction of most participants remained teacher-centered and lecture-based, and their technology usage was to support such instruction. In fact, changing teacher beliefs and practices from transmitting knowledge to encouraging students to assume responsibility for their own learning can be very challenging (Hoban, 2002). Among the twelve participants, only Miss Huang raised an argument similar to Fullan's (2001), that changing teachers' pedagogical beliefs is critical to achieving a successful reform, but that this may challenge teachers' core values about the purposes of education. Consequently, instruction and the technology integration of Miss Huang reflected her awareness of this issue and was different from the practice of most teachers in the school. Yet, to most teachers, it seemed easier to change their beliefs about technology than their pedagogical beliefs. For instance, all participants decided to adopt technology in their classes after the administrators proposed technology integration, and they started viewing it as an important element of education.

Such discrepancy in belief change could result from the strength difference in those beliefs. Beliefs formed early in life can be highly resistant to change while newly developed beliefs can be more easily modified (Pajares, 1922). The teachers formed their beliefs about how to teach a subject much earlier than the beliefs about what and how technology could be used in the classrooms. With few preconceptions about technology usage, teachers who regarded themselves as willing to change reacted to the policy instantly and incorporated technology into their instruction based on their experience of professional development,t which mostly emphasized basic computer knowledge and skills. Moreover, existing beliefs can affect the perception and acceptance of new ideas (Pajares, 1992). Teachers' existing beliefs may function as a filter and result in their partial transformation, which causes teachers to consciously or unconsciously modify the proposed instructional and assessment methods to fit their existing beliefs (Borko et al., 1997; Borko et al., 2000). Immersed in traditional educational systems, teachers might hold beliefs consistent with traditional instruction, so they are more likely to ignore or reject the proposed ideas and practices about how to implement technology integration. Alternatively, they might instinctively combine technology with their familiar instructional approaches when examples of creative technology integration were unavailable. Therefore, the technology integration of the school did not fundamentally change the ways most teachers conducted their instruction. Meanwhile, the teachers who wanted to experiment on new instructional strategies and technology integration were facing a challenge to change their beliefs in multiple aspects, including pedagogical beliefs, beliefs about technology integration, and so on.

Teachers may express beliefs aligned with proposed practices and research theories, but their practices do not reflect such beliefs. The practices of these teachers present a hybrid of traditional and reform-based ideas (Borko et al., 2000). Teachers such as Miss Huang whose pedagogical beliefs were consistent with constructivism would occasionally design learning tasks to encourage active exploration, self-regulated learning, and collaborative learning. However, teacher-centered, lecture-based instruction remained an important part of her instruction, and pencil-and-paper tests were the most common assessment method used in her class. Although Ms. Chen showed enthusiasm about constructivist instruction and about how technology could attend to individual differences, her instruction and technology usage were inconsistent with the reported beliefs. Mr. Lee and Mr. Wu both held certain beliefs aligned with constructivist instruction and their instructional strategies such as encouraging social interaction and emphasizing concepts behind problem-solving procedures reflected their constructivist beliefs, but the technology integration was limited to basic applications and did not necessarily connect with those beliefs.

The reasons that most teachers did not change their beliefs and practices and that their technology integration was mainly for supporting lectured-based instruction could be multi-faceted. The lack of true understanding of the proposed theories and practices could be one of the reasons. Fullan (2001) suggested that teachers may value and precisely state the concepts of a promoted change but fail to understand how to put these concepts into practice. For example, when the participants were asked to rate their agreement levels on eleven constructivist statements before interview sessions, most of them reported high agreement levels on almost all statements. However, during the interview sessions, most of the participants could not explain how they could apply those constructivist concepts to their instruction. Ms. Chen could articulate the importance of paying attention to individual students and encouraging self-regulated learning with technology, but she could not identify strategies to achieve these goals. She pleasantly declared that her students were mostly engaged in the student-centered activity which was to practice test-taking repetitively. Another participant stressed that her instruction was to inspire multiple viewpoints and critical thinking, but the classroom observation did not reflect such emphases. Actually, she tried to foster multiple viewpoints and critical thinking by "telling the students" these valuable qualities. The teacher was the primary performer in the class, attempting to persuade the students to accepting those ideas. Hence, a fundamental problem is that some terms have no clear definitions and guidelines to connect the terms and concepts with theoretical foundations and concrete instructional strategies. The learner-directed practice may be mistaken for constructivist instruction, and learning without scaffolding may be viewed as student-centered learning (Land & Hannafin, 2000).

In addition, trying to teach in new ways is never easy. Teachers have to learn new instructional approaches while handling the complexity of classroom life. Moreover, they may experience the conflict between the proposed knowledge and beliefs and the knowledge and beliefs they have established for a long time (Borko & Putnam, 1996). Miss Huang experienced a similar conflict after she finished her graduate study and decided to transform her instruction to foster student autonomy. Being used to creating numerous handouts and supplementary materials to prepare students for examinations, she struggled to restrain herself from imposing too much control over student learning and to assume learning responsibility for her students. The less impressive student performance in tests after implementing these new instructional approaches gave her colleagues and herself an impression that she was not teaching as effectively as before. Mr. Lee believed in the importance of spending time creating a positive atmosphere of collaboration in his class, and Mr. Wu emphasized that teachers should spend sufficient time allowing students to work on problems and to develop appropriate dispositions for learning mathematics. However, they both thought that covering the mandatory curriculum was their main responsibility, and failing to meet this requirement could result in unpleasant feedback from students, parents, or administrators.

Avoiding uncertainty and maintaining the feeling of control could be another crucial reason why most teachers hesitated to change their instruction and to explore other creative ways of technology integration beyond PowerPoint presentations. To adults, change means taking risks, and it usually causes uncomfortable feelings such as fear and anxiety (Bitner & Bitner, 2002; Heck & Williams, 1984). Asking teachers to change their existing practices is always full of uncertainty and ambiguity due to the interaction among different issues such as relationships with students, colleagues, and administrators, the classroom environment, curricular requirements, and school organization (Hoban, 2002). Certainly, most teachers tend to choose more familiar technology to help them conduct familiar instructional activities. Furthermore, PowerPoint slides could serve as organized teaching materials and instruction guides to give the teachers a sense of direction and to reduce uncertainty and anxiety. The slides could also provide a framework for instruction and evaluation to alleviate information overload.

Because of the limited ability of information processing, teachers develop simplified models or routines to guide their actions. While automatic routines reduce the information overload of teachers and allow them to handle the complexity of classroom environments (Borko & Putnam, 1996; Borko & Shavelson, 1990; Clark & Yinger, 1979, 1987), teachers may become too used to the routines to be aware of the inappropriateness of these routines when they are trying to undertake changes (Borko & Putnam, 1996). They may also develop various routines or coping strategies which are contradictory to their beliefs, creating inconsistency between teachers' expressed beliefs and their observed practices (Fang, 1996). Therefore, although Ms. Chen highly praised constructivist concepts and the technology integration implemented in the British high schools she visited, she seemed untroubled with the inconsistency between her reported beliefs and her own instruction. In the case of Mr. Wu, however, he recognized the negative effect of focusing on lectures and repetitive practice of test-taking, but he regarded traditional instructional approaches as best for achieving the primary goal of the school, and he continued employing these approaches.

Asking teachers to change their routines is not easy because it creates uncertainty for both teachers and students. Without familiar routines to support their practices, teachers may have less time and energy to monitor students' behavior and learning progress (Borko & Shavelson, 1990; Shavelson & Stern, 1981). Some teachers such as Mr. Lee and Ms. Chen were frequent technology users, but they often worried that unanticipated technical problems or the complexity of handling both teaching and operating a computer would interrupt their instruction and they would waste time and have problems with classroom management. Often, teachers attach great importance to being able to control classroom processes, and they value practices that allow them to prove their ability to do their work and maintain control (Calderhead, 1987; Olson & Eaton, 1987). If instruction did not go smoothly while incorporating technology into classrooms, teachers might be unsure how to handle the situation because of their limited knowledge and experience. Most teachers avoid relaxing control, and they give much thought to their existing practices and the implications of implementing an innovation (Borko et al., 2000; Calderhead, 1987; Olson & Eaton, 1987). The teachers might hesitate to tolerate ambiguity in their practices, to pay attention to individual students, and to think in different ways because of the possibility of wasting too much time and energy (Olson & Eaton, 1987).

To most teachers, giving up control and allowing students to assume more responsibility for their own learning is not easy. Many teachers believe that students will have difficulties understanding new knowledge and skills if they do not provide the knowledge and skills through explanations and modeling (Borko et al., 2000). Hence, teachers tend to consider it their responsibility to correct students' mistakes by providing right answers (Wood, Cobb, & Yackel, 1991), and this may explain why most participants did not allow the students to explore and find their own answers. Furthermore, in a school environment where grades are taken seriously, those teachers who decided to adopt constructivist instruction would undoubtedly face the problems of authority and control (Richardson, 1996). To most participants, more student autonomy and fewer tests would lead to lower student performance because the students could devote less time and energy to learning the subject. Believing that surrendering authority and control could hinder student learning, most teachers in the school assumed control and attended to details of student learning. According to Nisan-Nelson (2001), the level a teacher feels the need to control the instruction may affect to what degree technology will be incorporated into instruction. When teachers feel they need to assume more control over student learning and instructional activities, their technology usage tends to stay at lower levels.

When inconsistency between teacher beliefs and practices exists, teachers may change either their beliefs or practices to create coherence. How teachers resolve the inconsistency may be related to personal characteristics and history, teachers' capabilities, their willingness to take risks, and their commitment to work. It can be an interactive process of negotiation between constraints and incentives residing in the teachers and organizations (Tabachnick & Zeichner, 2003). Also, Woods (1996) argued that teachers will not automatically change a belief because each belief is interrelated to other beliefs in the belief systems. A change in beliefs cannot be forced. Encouraging teachers to reflect on their own beliefs and practices is critical to changing their beliefs and practices.

Implications and Recommendations

Becker (2000) argued that under the right conditions, such as adequate knowledge and skills of teachers, appropriate school schedules, adequate and convenient access to equipment, and constructivist pedagogical beliefs of teachers, technology would be a valuable instructional tool for teachers. However, the reality is that there are always some unfavorable and conflicting conditions, and teachers have to overcome various obstacles and resolve conflicts if they decide to integrate technology with their instruction (Cuban, 2003, Hung & Koh, 2004). Based on the findings of this study, this section provides suggestions for future practice and research to improve the conditions faced by most teachers.

Implications for practice

Since teachers' beliefs have close relationships with their instruction and technology integration, to implement a technological innovation and to encourage technology usage, it is necessary to investigate and sometimes modify teachers' beliefs. Moreover, contextual factors surrounding teachers may interplay with teacher beliefs to facilitate or hinder the technology integration. Therefore, the design and implementation of professional development programs, the school organization, and available support should focus on the influences and interrelationships of teacher belief and contextual factors.

Professional development

The study found that teacher belief played a critical role in teachers' decision making about technology integration. Therefore, those who introduce new ideas and practices to teachers should first consider their current interest, beliefs and understanding (Borko et al., 1997). A commonly used method to spread new ideas and practices is to provide teachers with opportunities of professional development. To encourage teachers to integrate technology with innovative instructional strategies to foster student understanding, professional development programs should not focus solely on basic computer skills, because teachers cannot automatically incorporate these skills into the teaching context appropriately. Instead, the design of professional development programs should identify teachers' beliefs about effective teaching, strategies to improve teaching and learning with technology usage, and curriculum design appropriate for pedagogical purposes of the content areas (King, 2002; Schwab & Foa, 2001; Windschitl & Sahl, 2002).

Teachers may be aware or unaware of the appropriateness of their pedagogical beliefs. Because most teachers have formed their pedagogical beliefs and instructional routines over a long time, these beliefs and practices may seem self-evident and resistant to change. Therefore, teachers need opportunities to reflect on their own beliefs and practices so they can detect areas of improvement and make efforts to enhance their instruction. However, teachers cannot change their beliefs and practices without support and contributions from others. Substantial change in teaching practice is derived from different ways of thinking and from alternative practices matching the new thinking. Richardson et al. (1990) suggested that to effectively implement an innovation, teacher belief should be consistent with the theoretical foundations of the proposed practice. Although successful implementation of an innovation often includes a change in teacher belief, an innovation that emphasizes belief change but fails to provide concrete examples of practices connecting to the theories may result in frustration and confusion.

The findings of this study indicate that teachers with more traditional pedagogical beliefs may implement technology integration to meet the goals of content coverage and examination preparation, and such integration may reinforce their existing beliefs and practices. However, teachers with constructivist beliefs tend to have difficulty connecting constructivist concepts to the development of new instructional strategies and to innovative technology integration. Moreover, teachers of different subject areas seem to have distinct viewpoints on how to teach and learn the subject matter. Hoban (2002) explained that classroom life encompasses many variables that interact with each other, so the implementation of an innovation cannot be effective without considering different issues simultaneously. Concepts or new practices introduced in a one-off professional development program cannot result in substantial change because existing beliefs and practices employ much stronger influences on teachers' decision-making and actions. Similarly, Calderhead (1987) suggested that instructional contexts profoundly affect instruction and how teachers define their educational purposes, so understanding the context in which teachers work is particularly important for changing teacher practice. Hence, plans for educational innovation and professional development should pay attention to the instructional context, which may be the source of resistance to change.

Therefore, to achieve substantial changes in teacher beliefs and practices, a thorough framework which considers various interacting elements of the educational environment is needed to provide ongoing support for teacher learning and change (Hoban, 2002). Also, it is impractical to expect teachers to creatively integrate technology with instruction in a short period of time. Teachers change their beliefs and practices at different rates. Teachers need opportunities to attend professional development programs which are ongoing, well-designed, and tailored for the school context and the needs of individual teachers (Mouza, 2002-2003; Richardson & Hamilton, 1994). While designing professional development programs of technology integration, it may be beneficial to start with investigating teachers' existing pedagogical beliefs, knowledge and beliefs about learning subject matter, instructional strategies, and so on. Based on the budget limit for professional development, educational administrators should encourage efforts to develop effective programs targeting teachers with different beliefs, abilities, and experiences. Thus, the designed programs can meet individuals' instant needs and resolve individuals' problems to substantially advance their beliefs and practices. However, the programs should be flexible enough for teachers to accommodate the learned concepts, knowledge, and skills to their particular situations.

Finally, regarding technology integration, professional development programs should allow teachers to know the capacities and constraints of various technologies and how specific technologies may support their own teaching practices and curricular goals. They also need to know how to use the technologies. Moreover, teachers need to be aware of the enabling conditions of the technology they plan to use (Windschitl & Sahl, 2002). Furthermore, the teachers may need to know how to handle social and organizational situations (Zhao et al., 2002); for example, searching for help and support from people with whom they have not interacted traditionally (Windschitl & Sahl, 2002).

School settings and support

To achieve a successful innovation, multiple aspects should be considered simultaneously. It is inadequate to solely focus on one aspect of a reform (Blumenfeld et al., 2000). Hence, in addition to professional development, how to consider various factors altogether to facilitate change in teacher belief and practice is critical for the implementation of an innovation. The administrators should express cohesive expectations and attitudes toward instructional purposes, and school organizations and administration should support teachers to achieve these purposes. Teachers may feel the need to demonstrate their accountability to students as well as other stakeholders including parents, administrators, curriculum developers, and politicians, and different groups of people. Teachers' work is usually influenced by those people, and they often face situations and expectations contradictory to each other and to their own beliefs (Calderhead, 1987). Teachers often feel disoriented when they encounter conflicts between their beliefs as a teacher and the expectations of other stakeholders.

Although joint examinations deeply influence the goal-setting of most high schools and the instruction of most high school teachers in Taiwan, students need to learn abilities other than test-taking to be successful in their future study and careers. Peterson (1979) argued that traditional teaching such as direct instruction results in better student achievement on standardized tests, but it cannot foster creativity and the ability of problem solving. Therefore, to achieve a variety of instructional goals and to meet needs of different students, teachers need to consider employing multiple approaches rather than attaching to a specific approach. Technology usage can result in limited or no improvement in teaching and learning unless teachers make decisions to transform their instruction to foster student understanding, and contextual factors surrounding the teachers constitute a beneficial environment for them to undertake such transformation. School administrators should involve teachers in the process of decision-making about how to implement an innovation. Heck & Williams (1984) explained that teachers can understand a new practice or program better if they are involved in the development process. Hence, their understanding allows them to make good decisions on how to implement the new practice successfully. Moreover, teachers can provide feedback for bettering the existing school environment to support the new practice (Bitner & Bitner, 2002; Blumenfeld et al., 2000).

The study found that traditional assessment such as overemphasizing pencil-and-paper tests and ranking students and classes according to scores should be reconsidered. Teachers need flexibility in employing various assessment methods to match instructional purposes, to appropriately evaluate student performance, and to encourage self-regulated learning. Furthermore, following a common schedule to cover all content of the chosen textbook will definitely prevent teachers and students from working on creative, meaningful, and long-term learning projects with technology. However, some teachers may have no intention of changing their practices. To accomplish an educational innovation, teachers need to be motivated rather than being forced to incorporate an unfamiliar practice in their classrooms. Hodas (1993) and Woods (1996) emphasized the social motivation for teachers to change their practice. The new practice should be desirable to teachers, and there should be enough support and resources for teachers to undertake the new practice. Moreover, the new practice should not threaten the fundamental beliefs of teachers, and teachers need time to assimilate it.

The school culture and organization may decide teachers' responses to a technological innovation because many teachers are not familiar with technology usage and they need support beyond fixing technical problems. Furthermore, because of teachers' unfamiliarity with technology usage, to achieve large-scale and routinized technology usage, more attention should be paid to how the educational environments can complement teacher practice to facilitate the implementation of feasible integration rather than illustrating perfect technology applications. The proposed usage should not too sharply diverge from teachers' learning experiences, their existing practices, the ability to implement the change, teachers' beliefs about learners and about curricular requirements, and the available support provided by the environment (Romano, 2003).

To achieve a successful educational reform, it is critical to foster a school culture which emphasizes professionalism, idea sharing, risk taking, and frequent reflection on pedagogy and student learning. However, some teachers may be concerned with experimenting on their students with new practices, because their accountability as trustworthy teachers may be at stake. Again, teachers should be provided with necessary support and examples of successful technology integration so they can concretize how to use technology to improve teaching and learning in their classes (Bitner & Bitner, 2002). Moreover, teachers need to be motivated so they can endure the uneasy process of changing their familiar practices (Bitner & Bitner, 2002; Schwab & Foa, 2001). Although teachers will obtain intrinsic motivation when they observe the improvement in student learning, they may need extrinsic motivation at first (Bitner & Bitner, 2002).

In addition, teachers need to spend time interacting with colleagues so they can challenge and support each other during the processes of implementing and experimenting on new technologies and new pedagogies (Ertmer, 2005; King, 2002; Zhao & Frank, 2003). Under time pressure, teachers of different subjects may cooperate in undertaking interdisciplinary projects with technology. Moreover, Staples & Pugach (2005) suggested that a mechanism which allows expert teachers of technology usage to provide assistance for their peers should be established. According to the findings of this study, expert teachers of technology usage may not be those teachers who are very competent in computer knowledge and skills, but those who can appropriately combine available technology applications with creative instruction design. Finally, it is critical to develop a shared vision among all stakeholders (Blumenfeld et al., 2000; Ertmer, 1999) during the process of achieving meaningful technology usage.

Recommendations for future research

Combining my experience conducting this study with the findings, I propose the following recommendations for future research. First, the joint examination seems to be an indispensable element in educational studies of Taiwan because of the difficulty in eliminating the competition for the examination (e.g., Chen, 2003; Huang, 2001; Yang, 2004; Pan & Yu, 1999). The findings of this study confirmed that the joint examination profoundly affected teachers' instruction and technology integration, regardless of whether teachers taught the tested subjects or not. Moreover, whether or not teachers viewed examination preparation as their primary goal, the joint examination was a substantial concern for their decision-making. In the United States, standardized tests have become an important issue, and more studies on how standardized tests affect teacher beliefs, instruction, and technology integration should be undertaken.

Second, while recognizing the rationality of introducing new pedagogical beliefs with technology usage, Zhao & Cziko (2001) argued that pedagogical beliefs and practices are more difficult to change and teachers may refuse to use technology if they are required to adopt new teaching approaches as well. Hence, Zhao & Cziko indicated that both new pedagogy and new technology should not be introduced to teachers at the same time. They believed that incorporating technology into the curriculum alone could cause disturbances and stimulate pedagogical changes. To reduce the disturbances caused by technology integration, Zhao & Cziko and other researchers (e.g., Ertmer, 2005; Romano, 2003; Shaffer & Resnick, 1999) proposed to provide teachers with technology which is easy to use and which supports their valued routines first, so learning the technology will not demand much time and energy and the anxiety level of teachers will be low. After getting accustomed to technology usage, teachers may develop further applications, discover the potential of technology, and change their beliefs about teaching, learning, and technology integration. However, teachers at different levels of technology integration may face different obstacles and need different support to continue transforming their practice. In addition, some teachers may become attached to basic integration with no intention of changing their practices or beliefs. Therefore, more studies need to investigate whether merely introducing simple technology without changing teachers' pedagogical beliefs is beneficial for technology integration.

Furthermore, future research needs to understand the needs and characteristics of teachers at different levels of technology integration to facilitate the transformation process.

Third, to fully understand teachers' technology integration, qualitative research methods are useful to illustrate how teacher beliefs and contextual factors influence teachers' decisions on technology integration, and qualitative methods may be more appropriate for investigating the interrelationships among various factors. Moreover, the findings indicate that recoding the many types of computer software used by a teacher or how many hours of technology usage in a class cannot truly reflect the level of technology integration of the teacher. Some teachers may not be frequent users and use very limited types of technology, but when they incorporate technology into instruction, their integration can effectively foster student understanding. Therefore, simply collecting numerical data or short answers for studies related to levels of teachers' technology integration may not be enough.

Fourth, as indicated by Lumpe & Chambers (2001), since there is a close relationship between teacher belief and teaching practice, understanding how to evaluate and address teacher belief is critical for the improvement of technology usage. Therefore, Lumpe & Chambers (2001) developed a "technology-related context beliefs instrument" to study teachers' belief patterns. How to precisely identify and measure teacher belief can be a challenging task. First of all, teacher beliefs are seldom articulated and examined, and teachers may either not be aware of their own beliefs or unable to express them (Fullan, 2001; Kagan, 1990; Richardson, 1994). Moreover, unlike knowledge, which is concerned with the truth or falseness of a concept (Pajares, 1992), beliefs are characterized as affective and evaluative (Nespor, 1987). Therefore, teachers may have little understanding of a construct which they declare to believe in. Despite the difficulty of measuring teacher belief, more studies should focus on how to develop methods or instruments to appropriately discover and evaluate teacher belief. Whether teacher belief should be inferred from their talk and actions (Kagan, 1990; Pajares, 1992) or be directly measured can also be an issue to explore. In addition, while asking participants to report their beliefs, researchers need to ensure that the participants do not misunderstand the queried statement.

Fifth, this study describes the importance of teachers' beliefs in affecting technology integration and the necessity of belief change to change teaching practice. However, there was no substantial evidence to suggest how teacher might change their beliefs more easily. Similarly, Ertmer (2005) raised the issue that researchers should investigate how teachers could change their beliefs related to technology integration more easily (e.g., through personal or vicarious experiences, individual or group exploration). Moreover, although the collected data suggested belief change and practice change are interactive, reciprocal, and ongoing (Borko et al., 2000; Fullan, 2001; Richardson, 1994), I cannot confidently claim which aspect of change is easier to initiate and to achieve for fundamental transformation of instruction and technology integration. Researchers may need to further explore this issue. Another relevant issue is related to the aforementioned difficulty of measuring teacher belief: specifically, measuring the change from earlier beliefs to those that invite technology integration.

Sixth, the findings of this study were consistent with the statement of Lampert (1997) that teachers do not accept formal knowledge or rules without questions and considerations, nor do they disregard formal knowledge and rules and solely react to their own intuition. Teachers usually make decisions based on current situations, conventional expectations of the public, and their understanding and beliefs. Teachers need to understand educational theories to apply the concepts to improving teaching and learning. However, the suggestion of Davis et al. (1993) that rather than providing teachers with more educational theories researchers should focus on helping teachers to cope with the difficulties and complexity of classroom life and to overcome the constraints surrounding them is very practical. Regarding how to encourage practical technology integration, Ertmer et al. (2001) argued that more studies should document examples of how teachers accomplish meaningful and effective technology integration without trendy and powerful equipment, because most teachers may benefit more from such studies. The importance of practical technology that fosters student understanding and achievement, rather than merely trendy or expensive technology, should be recognized (Staples & Pugach, 2005). These proposed studies can result in concrete and attainable suggestions to meet the needs of most teachers.

CONCLUSION

The purposes of this study were to illustrate the technology integration of Taiwanese high school teachers, to explore the influence of the teachers' pedagogical beliefs and beliefs about the potential of technology, and to investigate how contextual factors affect teacher belief and practice related to technology usage. The findings of this study can inform researchers and practitioners about how to improve the technology integration of Taiwanese high school teachers. The findings can also provide different perspectives on the implementation of an educational innovation at different grade levels and at different educational systems.

The common method of technology integration in the school was to use presentation software and LCD projectors to support teacher-centered, lecture-based instruction. Such integration allowed the teachers to efficiently and effectively transmit knowledge to students and to preserve their familiar routines and control. However, the study found that teachers with different pedagogical beliefs incorporated technology into their instruction in different ways. For example, some teachers with more constructivist beliefs made efforts to allocate time for students to engage in problem- or project-based learning once or twice a year. Some of them used online discussion or presentation software to anchor and encourage discussion and interaction among teachers and students. Teachers believing in examination preparation and content coverage tended to use technology to efficiently cover content, but they tended to discard technology when they considered technology not cost-effective or a source of distraction for student learning.

Not only teachers' pedagogical beliefs but also other beliefs such as those about the potential of technology usage for achieving their instructional goals affected the technology integration. Some teachers could not put their ideal instruction into practice because they did not believe that their knowledge and abilities, with the available equipment and support, allowed them to implement their ideas. Moreover, some teacher beliefs may be stronger than others, because they are formed earlier in life and become resistant to change. These beliefs may function as a filter to affect how teachers perceive new beliefs and practices. Therefore, some participants believed technology could be an unavoidable trend, and they started incorporating technology into instruction but left their traditional pedagogical beliefs intact. Or, their expressed beliefs could be inconsistent with the practices.

Reasons why the teachers did not change their beliefs or practices could be their lack of real understanding of proposed theories, the difficulties of simultaneously implementing new practice and handling the complexity of classroom life, and the tendency of avoiding uncertainty and maintaining control. To extend their concepts of technology integration, teachers need opportunities to reflect on their existing beliefs and practice and to experiment on new ideas. The reflection process is critical for teachers to change their practice because they may become aware of the inappropriateness of their existing beliefs and familiar with the characteristics of the proposed technology usage. Also, they may understand the influences of contextual factors and their relationships with the implementation of technology integration. However, the opportunities of professional development provided in the school exclusively focused on transmitting knowledge and skills for operating a computer rather than encouraging teachers to reflect on their beliefs and practice. Therefore, the teachers would not detect their problematic or inconsistent beliefs and practices.

The analysis of the influences of context factors on technology integration focused on the context of Taiwanese high schools. The College Joint Entrance Examination profoundly affected how the teachers and other stakeholders perceived the instructional purposes and the teachers' instruction and technology integration. Moreover, the mandatory curriculum standards, adopted textbooks, and inflexible assessment methods allowed teachers limited time and freedom to integrate technology with creative instruction design. In addition, the available equipment and support from others could be another issue, and the attitudes of other stakeholders could give teachers either pressure or support. Finally, school culture as well as issues of racial, social, and culture difference should be considered when promoting technology integration.

Therefore, the designers of professional development programs should take into consideration teachers' current knowledge, beliefs, interest, and instructional strategies to meet individuals' needs, encourage teachers to examine their own beliefs and practice, provide concrete examples of technology integration, sustain ongoing support, and allow teachers to learn the capacities and constraints of technology and other contextual factors to make appropriate decisions on technology integration. The school organization, assessment methods, allocation of resources and support, and the expectation of administrators should cohesively support teachers' instruction and technology integration. Teachers should be involved in the decision-making process, and a positive school culture to foster collaboration and idea- and support-sharing among teachers is critical.

Regarding future research, the influence of standardized tests on teachers' instruction and technology integration can be a popular research direction because it seems to be a common concern of the public. Also, more studies need to investigate whether introducing simple technology without changing teachers' pedagogical beliefs is beneficial for technology integration, and to understand the needs and characteristics of teachers at different levels of technology integration. Qualitative research methods may be more appropriate for illustrating the interrelationships among teacher belief, contextual factors, and technology integration. In addition, more study should investigate methods to influence teachers' beliefs regarding technology integration more effectively. How to evaluate teacher belief and change in belief can be challenging research topics. Also, studies on various contextual factors to explain why teachers refuse to change their beliefs and practices may lead to insightful findings. To benefit most teachers, more studies should document examples of how teachers accomplish meaningful and effective technology integration without trendy and powerful equipment.

Appendix A: National Educational Technology Standards (NETS)

ISTE National Educational Technology Standards (NETS) for Students (ISTE, 1998)

1. Basic operations and concepts
    - Students demonstrate a sound understanding of the nature and operation of technology systems.
    - Students are proficient in the use of technology.
2. Social, ethical, and human issues
    - Students understand the ethical, cultural, and societal issues related to technology.
    - Students practice responsible use of technology systems, information, and software.
    - Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.
3. Technology productivity tools
    - Students use technology tools to enhance learning, increase productivity, and promote creativity.
    - Students use productivity tools to collaborate in constructing technology-enhanced models, preparing publications, and producing other creative works.
4. Technology communication tools
    - Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.
    - Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.
5. Technology research tools
    - Students use technology to locate, evaluate, and collect information from a variety of sources.
    - Students use technology tools to process data and report results.
    - Students evaluate and select new information resources and technological innovations based on the appropriateness to specific tasks.
6. Technology problem-solving and decision-making tools

- Students use technology resources for solving problems and making informed decisions.
- Students employ technology in the development of strategies for solving problems in the real world.

ISTE National Educational Technology Standards (NETS) and Performance Indicators for Teachers (ISTE, 2000)

All classroom teachers should be prepared to meet the following standards and performance indicators.

1. Technology operations and concepts

   Teachers demonstrate a sound understanding of technology operations and concepts. Teachers:

   A. Demonstrate introductory knowledge, skills, and understanding of concepts related to technology (as described in the ISTE National Educational Technology Standards for Students).

   B. Demonstrate continual growth in technology knowledge and skills to stay abreast of current and emerging technologies.

2. Planning and designing learning environments and experiences

   Teachers plan and design effective learning environments and experiences supported by technology. Teachers:

   A. Design developmentally appropriate learning opportunities that apply technology-enhanced instructional strategies to support the diverse needs of learners.

   B. Apply current research on teaching and learning with technology when planning learning environments and experiences.

   C. Identify and locate technology resources and evaluate them for accuracy and suitability.

   D. Plan for the management of technology resources within the context of learning activities.

   E. Plan strategies to manage student learning in a technology-enhanced environment.

3. Teaching, learning, and the curriculum

   Teachers implement curriculum plans that include methods and strategies for applying technology to maximize student learning. Teachers:

   A. Facilitate technology-enhanced experiences that address content standards and student technology standards.

   B. Use technology to support learner-centered strategies that address the diverse needs of students.

C. Apply technology to develop students' higher order skills and creativity.

D. Manage student learning activities in a technology-enhanced environment.

4. Assessment and evaluation

   Teachers apply technology to facilitate a variety of effective assessment and evaluation strategies. Teachers:

   A. Apply technology in assessing student learning of subject matter using a variety of assessment techniques.

   B. Use technology resources to collect and analyze data, interpret results, and communicate findings to improve instructional practice and maximize student learning.

   C. Apply multiple methods of evaluation to determine students' appropriate use of technology resources for learning, communication, and productivity.

5. Productivity and professional practice

   Teachers use technology to enhance their productivity and professional practice. Teachers:

   A. Use technology resources to engage in ongoing professional development and lifelong learning.

   B. Continually evaluate and reflect on professional practice to make informed decisions regarding the use of technology in support of student learning.

   C. Apply technology to increase productivity.

   D. Use technology to communicate and collaborate with peers, parents, and the larger community in order to nurture student learning.

6. Social, ethical, legal, and human issues

   Teachers understand the social, ethical, legal, and human issues surrounding the use of technology in PK-12 schools and apply that understanding in practice. Teachers:

   A. Model and teach legal and ethical practice related to technology use.

   B. Apply technology resources to enable and empower learners with diverse backgrounds, characteristics, and abilities.

   C. Identify and use technology resources that affirm diversity.

   D. Promote safe and healthy use of technology resources.

   E. Facilitate equitable access to technology resources for all students.

Appendix B: Summary of the Collected Data

Case #	Observation	Interview	Document and Artifact
1		12-12-05 (informal) 01-09-06 01-12-06 (informal)	1 lesson plan for a project-based learning activity and final products for the learning task from 3 groups 2 syllabi and 1 lesson plan (online)
2	12-12-05 (1hr) 12-19-05 (2hrs) 01-08-06 (1hr)	01-11-06	Power Point slides used in class 1 syllabus (online)
3		01-10-06	The report on the visit to British schools, Power Point Slides used in class 2 syllabi (online)
4		12-29-05	1 lesson plan and 1 syllabus (online)
5	12-07-05 (1hr) 12-14-05 (1hr) 12-21-05 (2hrs)	01-10-06	1 lesson plan and handouts of 2 classes 1 lesson plan and 1 syllabus (online)
6	12-12-05 (2hrs) 12-19-05 (1hr)	01-09-06	Power Point slides and animation files used in class
7	12-08-05 (1hr) 12-15-05 (1hr) 12-22-05 (1hr)	01-10-06	Power Point slides and video clips used in class 2 syllabi (online)
8	12-08-05 (1hr) 12-15-05 (1hr) 12-22-05 (1hr)	01-04-06	
9	12-07-05 (1hr) 12-09-05 (1hr) 12-13-05 (1hr) 12-14-05 (1hr) 12-20-05 (1hr)	01-03-06	1 lesson plan and 2 syllabi (online)
10	12-11-05 (1hr) 12-19-05 (1hr)	01-03-06	2 syllabi (online)
11	12-09-05 (1hr) 12-15-05 (1hr) 12-22-05 (1hr)	01-08-06	1 lesson plan (online)
12	12-07-05 (2hrs) 12-14-05 (2hrs) 12-21-05 (2hrs)	01-05-06	1 lesson plan (online)

All interviews were audiotaped except for the two informal ones.

Appendix C: Pre-Interview Survey

Demographic Information:

1. Age: ☐ under 26 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☐ over 55
2. Gender: ☐ Male ☐ Female
3. Total number of years teaching:
4. Total number of years using technology in classrooms:
5. Subject:
6. Current grade you teach:
7. Number of classes you teach:
8. Educational Level:
9. Email Address (optional):
10. Phone Number (optional):

Agreement Levels on Constructivist Beliefs:

For each statement below, please choose a number from 0 to 9 to identify your agreement level on the statement (0: totally disagree; 9: totally agree).

1. Instruction should focus on students' active participation in learning rather than teachers' lecture.__________
2. Without engaging in problem-solving learning activities, it is difficult for students to achieve deep understanding. ________
3. Teachers should find out students' prior learning experiences and abilities before instruction.________
4. Instructional design should consider multiple intelligence or learning styles of individual students.______

5. Learning tasks or assignments should challenge students' existing conception or abilities.____
6. Instruction should foster students' abilities for solving problems and learning how to learn. ______
7. Instruction should foster students' abilities for monitoring and evaluating their own learning. _____
8. Instruction design should consider students' real-life experiences and interest. _____
9. In class, interaction between the teacher and students, among students, and between students and the learning environments should be encouraged. _
10. In class, students should be encouraged to collaborate/cooperate with each other and to respect each other's opinions.______
11. Teachers should employ multiple assessment methods to understand a student's learning status._____

Appendix D: Agreement Levels on Constructivist Concepts

12 Participants' Agreement Levels on the Constructivist Statements Listed in Appendix B (0: totally disagree; 9: totally agree)

Statement	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12
Active participation	9	7	9	8	8	9	6	7	9	9	8	7
Problem-solving	9	8	9	8	8	6	9	9	9	9	8	8
Prior experiences	9	9	9	8	8	8	8	9	9	9	9	9
Multiple intelligence	7	5	9	5	8	7	7	5	9	9	8	7
(Mis)conceptions	5	8	9	7	5	6	7	8	9	9	3	9
Cognitive strategies	9	9	9	9	9	8	8	9	9	9	9	9
Metacognition	7	9	9	7	9	7	6	9	9	9	8	8
Authenticity	7	7	9	5	7	8	8	9	9	9	9	9
Interaction	9	9	9	8	8	8	9	9	9	9	9	9
Peer learning	9	9	9	8	8	7	9	9	9	9	9	9
Assessment	9	9	9	6	8	8	8	9	9	9	9	9

Appendix E: Semi-Structured Interview Questions

1. As a teacher (or a high school teacher of [subject]), how do you define your work or your educational goals?
2. What kinds of abilities or dispositions do you want your students to acquire through your teaching or guidance?
3. What technology applications do you use in your work (e.g. searching for information to enrich your instruction, grading, communicating with colleagues or parents, instructional design, presenting instruction content, etc.)?
4. Please more specifically describe how you use educational technology in your instruction.
5. Besides using Power Point slides to present instruction content, what are (were) other applications of educational technology conducted in your class?
6. Why did you decide to start using educational technology in your instruction?
7. How did you learn the skills or knowledge of technology integration?
8. What are the differences in your instruction with and without technology? What are the differences in students' reaction and learning outcomes?
9. What are the pros and cons of using educational technology in instruction?
10. What is your ideal technology integration? Do you have any plan or new ideas for future technology integration? Please describe your plan.
11. While integrating educational technology with your instruction, what difficulties or barriers did you face?
12. Our government has been promoting technology integration in education, what is your opinion regarding this policy?
13. What is your opinion about the overall educational reform?

Appendix F: Coding List

Coding List Generated from Observation & Interview Data

Descriptive coding:

Instructional content: textbook	IC_Txtb
Instructional content: teacher's design	IC_TDes
Instructional content: teacher's supplement	IC_TSup
Evaluation method	Eva_M
Evaluation criteria	Eva_C
My impression of the teacher	MyIm_T
Learning environment	LE
Classroom management	CM
Talk irrelevant to instruction content	TIrre
Teaching aids other than slides	TA
Student feedback/reaction or performance	StF/R/P
Homework and requirements	HR
Presentation of students' work	Pres_W
Grouping	GP
Students' pressure	StP
School organization	Sch_Org
Students' access to equipment	St_Equ
Teachers' technology use outside classrooms	TT_OC
Sources of teaching materials	S_TM

Theoretical coding:

Ways technology used in class: presentation	Tech_Pre
Ways technology used in class: Internet search	Tech_IS
Ways technology used in class: online discussion	Tech_OD
Ways technology used in class: software for analysis	Tech_SWA
Ways technology used in class: submitting/revising homework	Tec_Sub/Rev
Power Point slides: presenting content/examples	PP_Con/Ex
Power Point slides: summarizing/highlighting	PP_Sum/Hi
Power Point slides: modeling	PP_MD
Power Point slides: motivating students	PP_MS

● Beliefs: teaching and learning	BF_T&L
● Beliefs: subject learning	BF_SB
● Beliefs: technology integration	BF_TI
● Beliefs: assessment	BF_A
● Factors affecting teaching: time	FT_T
● Factors affecting teaching: assessment	FT_A
● Factors affecting teaching: curricular standards/content	FT_CStd/C
● Factors affecting teaching: class size	FT_CSize
● Factors affecting teaching: student reaction/learning habits	FT_StR/LH
● Factors affecting teaching: parent/colleague or society expectation	FT_P/C/S
● Factors affecting technology integration: function	Cons_Fun
● Factors affecting technology integration: workload & time pressure	FTI_WL&T
● Factors affecting technology integration: cost/benefit	FTI_C/B
● Factors affecting technology integration: resources /support	FTI_R/S
● Factors affecting technology integration: uncertainty	FTI_Unc
● Factors affecting technology integration: lack of good examples/guidance	FTI_L:Ex/G
● Factors affecting technology integration: knowledge/skills and interest	FTI_K/S/I
● Factors affecting technology integration: school culture	FTI_SC
● Factors affecting technology integration: student reaction	FTI_SR
● Perception of students' learning habits and expectation	P_LH&E
● Perspectives on policies or educational reform	P_P/Ref
● Teacher's learning: technology skills	TL_TS
● Teacher's learning: pedagogical (content) knowledge	TL_PK
● Ideal technology integration: equipment	ITI_Equ
● Ideal technology integration: design & implementation	ITI_Des&Imp
● Ideal technology integration: vivid/rich information	ITI_V/RInfo
● Pros of using technology: easy to present and share content/ideas	Pros_Shr_C/I
● Pros of using technology: keeping/organizing data	Pros_Ke/Or_D
● Pros of using technology: making content more concrete	Pros_CC
● Pros of using technology: getting more/richer information	Pros_M/RInfor
● Pros of using technology: motivating students	Pros_MS
● Pros of using technology: exploring/discovering	Pros_ExpDis
● Pros of using technology: evaluation	Pros_Eva
● Pros of using technology: no need using blackboard(covering content)	Pros_NBB
● Pros of using technology: reuse the materials	Pros_ReUM

● Pros of using technology: more interaction	Pros_MI
● Cons of using technology: student reaction	Cons_SR
● Cons of using technology: workload and pressure	Cons_WL&P
● Cons of using technology: equipment failure	Cons_EquF
● Consideration of instructional design: activity sequence	CID_AS
● Consideration of instructional design: content characteristic	CID_CC
● Consideration of instructional design: student reaction/learning outcome	CID_StR/LO
● Consideration of instructional design: evaluation, feedback & revision	CID_Eva
● Teaching goals	TG
● Students' abilities emphasized by teacher	StAb
● Ideal instruction	IIns
● Planned (future) technology integration	FuTI

Thematic coding:

● Teacher feedback: comments on student work	TF_C
● Teacher feedback: praise/reward	TF_P
● Instructional method: modeling	IM_MD
● Instructional method: brainstorming	IM_BS
● Instructional method: lecturing	IM_Lec
● Instructional method: questioning	IM_Que
● Instructional method: reviewing	IM_Rev
● Learning activity: reciting	LA_Rec
● Learning activity: note taking/highlighting	LA_NH
● Learning activity: test taking	LA_T
● Learning activity: group work	LA_GW
● Learning activity: discussion/debate	LA_Dis
● Learning activity: problem solving	LA_PBS
● Motives of starting using technology in class	Motive
● Instruction planning	IP
● Time and energy devoted to instructional design	IE_ID
● Reflection on teaching experience	Ref_TE
● Revising instruction design	RevID
● Professional development program	PDP
● Colleagues' technology use	CTU
● Cooperation and sharing among teachers	Cop/Shr_T
● Gap between policy and teaching practice	Gap_P&TP

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Vita

Chao-hsiu Chen was born in Tainan City, Taiwan on March, 16, 1970, the daughter of Fengzhi Chen and Miaoqin Gao. After graduating from Tainan Girls' High School, Tainan, Taiwan, she entered National Taiwan Normal University majoring in computer education in Taipei, Taiwan in 1988. She was employed as a practicing teacher of computer subjects at ZhongLi Vocational Senior High School from August, 1992 to July, 1993. She received the degree of Bachelor of Education from National Taiwan Normal University in June, 1993. She started her graduate study in National Chiao Tung University in 1993, and she earned the degree of Master of Arts in Communication Studies in June, 1995. In the following years, she was employed in teaching computer subjects in Zhong-Li Vocational High School and Xing-Ying High schools. In September, 2002, she entered the University of Texas at Austin Doctoral degree program in Instruction Technology.

In 2004, she presented the paper, "Constructivist instruction design: Using problem and project-based learning to support programming learning" at the annual meeting of the Southwest Educational Research Association in Dallas, Texas. In the same year, she co-presented the paper, "A case study of communication channels in a graduate program" at the annual meeting of the American Society for Information Science and Technology in Providence, Rhode Island. In 2006, she presented two papers, "A case study on how a middle school teacher experiments on integrating technology with constructivist instruction" and "Expectation discrepancy of technology integration: A case study of an elementary math teacher education class" at the annual meeting of the Southwest Educational Research Association in Austin, Texas.

Permanent address: 22 Lane 22, Kuanghua Street, Jiali Zhen, Tainan County, Taiwan, ROC

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